

Food losses due to non-infectious and production diseases in developing countries

FAO
ANIMAL
PRODUCTION
AND HEALTH
PAPER

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Food
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FOREWORD

These proceedings comprise papers given during the Expert Consultation on Food Losses Due to Non-Infectious and Production Diseases in Developing Countries, held in Rome in June 1991. They represent the considerable work by 14 international experts who advised FAO and Member Countries during the Consultation.

The keynote paper, *An Inventory of Non-Infectious and Production Diseases of Livestock in Developing Countries*, by Dr. S.N.H. Putt, Reading, England, is a search of the scientific literature from 1970 to 1990 for papers on the subject. Papers were included in the inventory only if they contained an estimate of the frequency of occurrence of the condition and/or an estimate of the effect of the condition on productivity.

Selection of papers from the published literature may not accurately represent world-wide or regional priorities of non-infectious and production diseases; the inventory certainly does not represent local priorities. However, reports on losses due to female reproductive disorders, neo-natal mortality and nutritional deficiencies represent 48% of the 320 citations. The high frequency of citation of these three non-infectious disease categories supports intuitive evaluations from other sources.

The papers cover a wide variety of topics from non-infectious nutritional deficiency and reproductive diseases to genetic diseases, losses from animal trekking, toxicities, neo-natal mortality, poor management and others. These disease categories are discussed from the point of view of highlighting awareness of the magnitude of losses caused by non-infectious and production diseases, the need for more financial and prevalence data and for improved extension programmes for control.

Accurate estimates of production losses from specific diseases can only be measured in association with routine production and health monitoring under local production systems. Losses from chronic, non-infectious and production diseases are not usually measured in terms of mortality or morbidity rates, as are infectious diseases, but as production losses judged against biological capability or the productivity of the top percentile of animals in similar production systems. A plea was made to systematically collate such data from all sources.

The Organization is grateful to all those who participated in the Expert Consultation and contributed to its success.

These proceedings are published with a note of sadness occasioned by the recent death of Dr. S.N.H. Putt. Dr. Putt compiled the data for and presented the keynote paper for the consultation. Nick Putt was a persuasive advocate for collecting reliable data on production losses from disease, be they infectious or non-infectious. His professional approach, incisive thinking and good humour will be missed by all.

E.P. Cunningham
Director
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This One



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AN INVENTORY OF THE FREQUENCY OF OCCURRENCE OF NON-INFECTIOUS DISEASES AND THEIR IMPACT ON LIVESTOCK PRODUCTION IN DEVELOPING COUNTRIES

by

S.N.H. Putt^{1/}

1. Definition of Terminology and System of Categorisation Adopted

An inventory has been compiled of reports on the occurrence of non-infectious diseases with specific reference to their impact on livestock production in developing countries.

The inventory consists of two parts. The first part is concerned with specific non-infectious diseases. In this context, a non-infectious disease is defined as one in which the presence of an infectious agent is not necessary for the disease to occur. An infectious agent being defined as an animal or vegetable organism that lives on or in another and derives its nourishment therefrom.

Using this definition, reports on the occurrence of non-infectious diseases are grouped under a series of specific categories:

- metabolic diseases;
- nutritional deficiencies;
- diseases caused by physical agents;
- diseases caused by inorganic chemical agents;
- diseases caused by organic chemical agents;
- non-infectious neoplasias;
- genetic diseases;
- diseases of unknown aetiology (the causes of which are unknown but thought to be non-infectious).

Under these general categories, diseases are classified under a hierarchical system as follows. A sub-category which groups together similar diseases or conditions; the specific disease reported; the species affected; the region and then the country from which the disease was reported.

The particular report in question is then described under a series of headings. These include the reference of the report, the population studied, the type of study undertaken and an abstract of the findings.

The second part of the inventory is concerned not with specific diseases in particular but rather with syndromes, signs or areas of production loss which arise out of a combination

^{1/} Consultant

of determinants in which non-infectious factors like management, nutrition, climate and other environmental factors play a significant role in determining the frequency of occurrence and the extent of the production loss suffered. These are grouped together under the heading of Non-infectious Multifactorial Causes Of Production Loss. The main sub-categories under this heading include mortalities of young stock, lameness, and male and female reproductive disorders. Under these sub-categories a similar system of hierarchical classification is adopted for specific reports.

2. Range and Scope of the Inventory

The reports included in this inventory are those from literature published in the scientific journals. They primarily cover the last two decades from 1970 onwards. Entries are confined to those reports which give some estimate of the frequency of the occurrence to the condition being considered and/or an estimate of the effect of the condition on productivity; either assessed as the effect on a particular production parameter(s) or as some estimate of the scale of the financial or economic loss experienced.

The inventory is concerned primarily with reports from developing countries. Major areas excluded are Western Europe, the United States and Canada. In view of recent political developments, the countries of Eastern Europe are included. In addition, the inventory also includes reports from the Antipodes (Australia and New Zealand). This is because it is considered that the disease problems and environmental constraints experienced by the livestock production systems in these countries contain many similarities with those encountered in the developing world.

Because of the range of subjects to be covered, language difficulties and problems associated with obtaining scientific journals published in developing countries, heavy reliance was placed on library abstracting services. The principal library data bases included in the search are those of the Commonwealth Agricultural Bureau and the AGRIS and AGRICOLA information systems. These are mainly concerned with reports of publications in scientific journals and related publications. A consequence of this is that reports from the so-called "grey literature", i.e. technical and consultancy reports from specific livestock projects supported by the development agencies are probably under-represented in the inventory. There appears, however, to be no easy means of scanning or gaining access to this literature to determine what reports exist that might be of relevance and the nature of their contents.

3. Findings and Conclusions

The main finding of this exercise is that the extent and quality of data existing on the frequency of occurrence of non-infectious disease in the livestock populations of the developing world is extremely variable. Certain specific diseases or conditions appear to be reasonably well documented, while information on others is hard to come by in the scientific literature. There appears to be a body of good quality information available on neonatal and perinatal mortalities in lambs from a number of regions, for example, although the range of losses reported are very variable. Conversely, it is surprising that there is not more information available on the distribution and frequency of occurrence of mineral deficiencies. Additional information undoubtedly exists but is probably to be found mainly in the "grey literature" not covered by this inventory.

There is also a surprising lack of economic data. Although information on production losses from specific diseases or conditions is available, there appears to have been few attempts to assign an economic or financial value to such losses. The lack of any such information complicates any attempt to prioritise the importance of specific diseases or conditions.

The relative number of reports and references cited in the inventory cannot, therefore, be used as an indication of the relative importance of specific diseases or conditions. The situation is further complicated by the fact that a significant proportion of the reports contained in the inventory are primarily concerned with the investigation of individual disease outbreaks, or of data collected from abattoirs or diagnostic laboratories. In certain categories, the emphasis is generally on the reporting of outbreaks of new or novel disease incidents rather than on the quantification of existing and, presumably, commonly occurring diseases or conditions. In addition, most of the data produced from these types of studies is in the form of proportional morbidity/mortality rates. This reflects the limitations inherent in such studies which cannot relate their findings to source populations to give overall estimates of actual frequencies of occurrence.

A further complicating factor is that there appears to be widespread confusion amongst veterinary researchers and investigators in the developing world as to the proper definitions of rates used to calculate the frequency of disease occurrences. In particular, the terms incidence and prevalence rates are frequently confused or wrongly defined. This is often coupled with inadequate explanations as to how the studies were undertaken and the associated rates actually derived. Making inferences about the livestock population in general from the information produced by these specific studies is, therefore, extremely difficult.

Accurate quantification of the frequency of disease occurrences can normally only be obtained through the implementation of properly designed and undertaken epidemiological field studies. Accurate estimates of production loss associated with specific diseases can only be obtained if such studies are closely integrated with routine production and health monitoring in the production systems concerned. Aside from a lack of expertise in developing countries in the methodologies to be adopted in the design and implementation of such studies, the very nature of many non-infectious diseases complicates this approach. The signs associated with many non-infectious diseases are often chronic and non-specific in nature. As such, considerable expertise is required to arrive at an accurate clinical diagnosis. In addition, confirmatory diagnostic laboratory tests, where they exist, are often complex and/or expensive which limits their availability for use in field studies in developing countries. This is in contrast to many infectious diseases, where simple direct or indirect diagnostic tests often exist to confirm the presence of, or previous infection with, a specific etiological agent. This is exemplified by the plethora of reports in the literature on brucellosis surveys where diagnosis is undertaken by the Rose Bengal Agglutination Test and by the high number of reports of plant poisoning in this inventory; where a diagnosis in the case of an outbreak can be relatively easily obtained by the feeding of the suspected poisonous plant to experimental animals.

Research and investigation into non-infectious diseases is also constrained by the preoccupation of veterinary services in the developing world with infectious disease. Nearly all routine disease reporting systems examined by the author in the developing world are

concerned solely with reports of infectious disease. Largely because of this inherent bias, the funding available for most research and investigative work is similarly orientated. As a result, non-infectious diseases do not receive the attention that they undoubtedly merit.

In spite of these problems, there are clear indications from the inventory that non-infectious diseases and disease determinants are major factors of importance in determining the extent of mortality, particularly in young stock, and as causes of poor fertility performance and other types of production loss (weight gain, milk production, etc.). The multifactorial nature of many of these production problems which involve interactions between specific disease agents and other extraneous factors, particularly systems and standards of livestock nutrition and management, clearly merit further and detailed study.

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METABOLIC DISEASE

Sub-Category: General Metabolic Disorders
Disease: Metabolic Disorders
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Anderson (1985)

Population Studied: 36 dairy farms containing 7050 dairy cows and 1460 yearlings

Type of Study: Survey

Abstract: A two year study of 36 dairy farms revealed that 3.9% of cows were treated for metabolic disease. 0.4% of cows either died or were culled because of metabolic diseases.

Sub-Category: General Metabolic Disorders
Disease: Metabolic Disorders
Species Affected: Pigs
Region: Eastern Asia
Country: Korea

Reference: Chung *et al.* (1984)

Population Studied: 1153 slaughter sows

Type of Study: Survey

Abstract: 9.1% of 1153 slaughter sows were culled because of metabolic disorders.

Sub-Category: General Metabolic Disorders
Disease: Metabolic Disorders
Species Affected: Chickens
Region: Eastern Europe
Country: Poland

Reference: Mazurkiewicz *et al.* (1986)

Population Studied: 46 batches of broilers from 12 units

Type Of Study: Retrospective study of production records

Abstract: Losses were recorded between 1981-85 from 12 broiler units in Lower Silesia. Metabolic disorders accounted for between 14 - 29% of deaths. These disorders included gout, fatty degeneration of the liver and kidneys, haemorrhagic syndrome, rickets and perosis. A malabsorption syndrome was responsible for 0.8% of losses in 1985.

Sub-Category: Digestive Disorders
Disease: General Digestive Disorders
Species Affected: Cattle
Region: North Africa
Country: Tunisia

Reference: Zrelli *et al.* (1988)

Population Studied: Calf population on three dairy farms

Type of Study: Survey

Abstract: A two year survey of 3 dairy farms revealed calf losses of 18.8% in the first year and 23.6% in the second. 24.5% of these losses were due to digestive disorders.

Sub-Category: Digestive Disorders
Disease: Acidosis
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Richards *et al.* (1989)

Population Studied: 950 terminally ill or dead sheep during exportation

Type of Study: Diagnostic investigation

Abstract: Post-mortems were conducted on 950 dead or terminally ill sheep during assembly for export and during shipping from Western Australia to various Middle East destinations. 3.9% of all deaths during assembly were due to acidosis.

Sub-Category: Digestive Disorders
Disease: Bloat
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Carruthers *et al.* (1987)

Population Studied: Cattle population of 312 dairy farms on North Island

Type Of Study: Survey

Abstract: A survey of 312 dairy farms was carried out on North Island in October and November 1986. 87% of all farms experienced bloat ranging from mild (130) to severe (18). Mortality rates due to bloat in spring 1986 were 0.83% in milking cows and 0.23% in young stock.

Sub-Category: Digestive Disorders
Disease: Bloat
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Anderson (1985)

Population Studied: 36 dairy farms containing 7050 dairy cows and 1460 yearlings

Type of Study: Survey

Abstract: A two year study of 36 dairy farms revealed that 0.8% of cows either died or were culled because of bloat.

Sub-Category: Hypoglycemia
Disease: Ketosis
Species Affected: Cattle
Region: Eastern Europe
Country: Yugoslavia

Reference: Krdzalic *et al.* (1988)

Population Studied: 9610 dairy cows on 14 farms

Type of Study: Survey

Abstract: On 14 large dairy farms with 9610 cows, ketosis was diagnosed in 469 (40.5%) of the 1170 cows examined. On 19 small-holdings with 242 cows it was diagnosed in 23 (14.4%) of 172 cows examined.

Sub-Category: Hypoglycemias
Disease: Ketosis
Species Affected: Cattle
Region: Eastern Europe
Country: Rumania

Reference: Medrea *et al.* (1984)

Population Studied: 188 bovine fetuses

Type of Study: Retrospective study of laboratory records

Abstract: Pregnancy toxemia was identified as the cause of abortion in 31.4% of 188 aborted fetuses submitted for laboratory diagnosis.

Sub-Category: Hypoglycemias
Disease: Ketosis
Species Affected: Cattle
Region: Eastern Europe
Country: USSR

Reference: Zharov (1983)

Population Studied: Unspecified dairy cattle populations in Lithuania and Moscow

Type of Study: Survey

Abstract: A survey in Lithuania between 1971 and 1973 showed that 65% cows studied developed ketosis, ketones were detected in the milk of 23%. In Moscow dairy herds, ketosis occurred in a range of between 14% to 35% cows per year (mean 27%).

Sub-Category: Hypocalcemias
Disease: Post-Parturient Paresis
Species Affected: Cattle
Region: Southern Asia
Country: Sri Lanka

Reference: Bauman (1983)

Population studied: Cattle on three large scale dairy development farms 1978-1981

Type of Study: Retrospective study of farm records

Abstract: Over the three year period the annual loss in adult cattle due to culling or mortality ranged between 2-15% per year. Post-parturient paresis accounted for 7.6% of total mortalities/culls.

NUTRITIONAL DEFICIENCIES

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Reece *et al.* (1985)

Population Studied: 19450 dead birds submitted from approximately 1400 broiler flocks in Victoria

Type of Study: Retrospective study of post mortem records

Abstract: Out of 2654 flock diagnoses made, there were 92 diagnoses of starve-out syndrome. This was often associated with chilling and runting.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Richards *et al.* (1989)

Population Studied: 950 terminally ill or dead sheep during exportation

Type of Study: Diagnostic investigation

Abstract: Post-mortems were conducted on 950 dead or terminally ill sheep during assembly for export and during shipping from Western Australia to various Middle East destinations. 10.2% of all deaths during assembly and 43.4% of all deaths during voyages were due to inanition. Mortality rates due to inanition during the first 11 days of voyages ranged from 56.2 to 76.7 deaths per 10,000 sheep.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Alexander (1986)

Population Studied: Unspecified

Type of Study: Review article

Abstract: Losses of lambs under pastoral conditions range from 5 to 70%. Four major non-infectious conditions emerge: birth problems, cold exposure, starvation and birth weight extremes. Preventive strategies for cold exposure and starvation were analyzed: genetic selection for vigour and alertness, easy birth and maternal care of multiples offered the best solutions.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Gumbrell and Saville (1986)

Population Studied: 21 commercial sheep farms

Type of Study: Survey

Abstract: The study examined over 23000 dead lambs on 21 commercial sheep farms over a five year period representing 9.8% of the total drop on these farms. Lamb losses on individual farms varied from 3% to 20%. 15% of dead lambs showed lesions of starvation and/or exposure. 27% showed lesions of dystocia and starvation exposure suggesting that dystocia damaged lambs sufficiently to adversely effect their ability to feed and to seek shelter.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Oliveira and Barros (1980)

Population Studied: 2774 Polworth ewes in a flock in Rio Grande do Sul

Type Of Study: Survey

Abstract: Of 200 lambs that died within 10 days of birth, 78.5% died as a consequence of starvation and/or exposure.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Latin America
Country: Chile

Reference: Clara (1977)

Population Studied: 1581 Corriedale ewes on the Magallanes

Type Of Study: Retrospective study of farm records

Abstract: Data on 947 adult and 634 two-tooth Corriedale ewes grazed on either tussock or scrub pasture showed 3.87% stillbirths on tussock and 3.8% on scrub pasture. Mortality in lambs under three days old was 17.24 and 14.92%. Mortality rates from three days to weaning were 4.08 and 4.61%. Weaning rates were 61.71 and 69.41 lambs per 100 adult ewes and 51.10 and 52.5 per 100 per young female for the two types of pasture.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Latin America
Country: Peru

Reference: Ameghino *et al.* (1984)

Population Studied: Sheep population on a large ranch (estimated annual population of 177,000)

Type of Study: Longitudinal monitoring over a 10 year period

Abstract: Between 1971 and 1980 a total of 603694 lamb births were recorded. Mortality during the first three days of life was 36.94/1000 births and for the period from 4 to 30 days 5.87/1000. Starvation accounted for 7.8% of deaths.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Ethiopia

Reference: Njau *et al.* (1988)

Population Studied: Six sheep flocks

Type of Study: Longitudinal monitoring

Abstract: Reports on 1025 deaths from six flocks over a four year period. Annual mortality rates were 20.8%, 16%, 43% and 72.2% respectively. Mismothering/starvation accounted for 13.8% of the total mortality.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Republic Of South Africa

Reference: Meaker and Nickerk (1977)

Population Studied: Lambs from 50 Merino ewes

Type Of Study: Experimental study

Abstract: 50 pregnant Merino ewes were allotted to two planes of nutrition for the last six weeks of gestation. Neonatal mortality in single and multiple lambs for ewes on the low plane of nutrition was 18.2 and 26.7% respectively as compared to 6.7 and 10.0% for lambs from ewes on the high plane.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Singh *et al.* (1987)

Population Studied: 3511 lambs

Type of Study: Retrospective study of production records

Abstract: Data on 3511 lambs born over a seven year period were analyzed. The preweaning mortality rate due to starvation was 21.8%.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Kornel and Vasudevan (1984)

Population Studied: Lambs from 435 mated ewes (1973)

Type of Study: Cohort study

Abstract: Prenatal losses were 1.32%, post-natal to 28 days were 37.5%. 80% of mortalities to 7 days were from starvation or heat stress.

Sub-Category: General Nutritional Deficiencies
Disease: Inanition
Species Affected: Goats
Region: South Eastern Asia
Country: Malaysia

Reference: Zamri-Saad *et al.* (1988)

Population Studied: 1063 dead goats

Type of Study: Retrospective study of post-mortem records

Abstract: Malnutrition leading to emaciation was identified as the cause of death in 33.9% of 1063 goat carcasses examined at the University Veterinary Faculty, Pertanian between 1977 to 1986.

Sub-Category: General Nutritional Disorders
Disease: Infertility
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Rao *et al.* (1983)

Population Studied: 1975 crossbred cows

Type of Study: Retrospective study of clinical records

Abstract: Of 1975 crossbred cows examined between January and December 1981, 18.18% had non-functional ovaries and 17.97% genital hypoplasia. The two conditions were due to underfeeding.

Sub-Category: General Nutritional Deficiencies
Disease: Stillbirths
Species Affected: Cattle
Region: North Africa
Country: Tunisia

Reference: Zrelli *et al.* (1988)

Population Studied: Cattle population on three dairy farms

Type Of Study: Survey

Abstract: A two year survey of 3 dairy farms revealed calf losses of 18.8% in the first year and 23.6% in the second. 20.5% of these losses were due to stillbirths. Inadequate nutrition of dams late in pregnancy was thought to have been a major contributory factor.

Sub-Category: General Nutritional Deficiencies
Disease: Unthriftiness
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Botswana

Reference: Reed *et al.* (1974)

Population Studied: Cattle in six areas of Botswana

Type of Study: Survey

Abstract: Data on serum mineral levels and diet were obtained from approximately 200 lactating cows in each of six areas of Botswana. It was concluded that cause of unthriftiness in many cattle was probably related to malnutrition rather than aphosphoris.

Sub-Category: Fatty Acid Deficiencies
Disease: Linoleic Acid Deficiency
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Reece *et al.* (1985)

Population Studied: 19450 dead birds submitted from approximately 1400 broiler flocks in Victoria

Type of study: Retrospective study of post-mortem records

Abstract: Out of 2654 flock diagnoses made, there were 116 diagnoses of linoleic acid deficiency.

Sub-Category: Mineral Deficiencies
Disease: Calcium/Phosphorus Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Poland

Reference: Badura *et al.* (1974)

Population Studied: 246 yearling bulls on 2 farms

Type of Study: Outbreak investigation

Abstract: 73 yearling bulls out of a population of 246 on two farms were affected with rickets.

Sub-Category: Mineral Deficiencies
Disease: Calcium/Phosphorus Deficiency
Species Affected: Cattle
Region: Latin America
Country: Colombia

Reference: Corrier *et al.* (1978)

Population Studied: Cattle on 37 ranches in the eastern plains of Colombia

Type of Study: Survey

Abstract: Six leg fractures and two fractures of the spinal column due to calcium/phosphorus deficiency occurred in a population of 4258 animals examined during the course of a two year survey.

Sub-Category: Mineral Deficiencies
Disease: Calcium/Phosphorus Deficiency
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Botswana

Reference: Reed *et al.* (1974)

Population Studied: Cattle in six areas of Botswana

Type of Study: Survey

Abstract: Data on serum mineral levels and diet were obtained from approximately 200 lactating cows in each of six areas of Botswana. Mean levels of serum inorganic phosphate, calcium and magnesium were 4.06 mg %, 9 mg % and 2.4 mg %. This constitutes normal levels for magnesium but rather low levels of calcium and phosphorus. Phosphorus levels appeared to be related to quality of grazing but Calcium and magnesium were unaffected. Bonemeal supplementation increased phosphorus levels but depressed calcium and magnesium levels. Overt clinical signs of phosphorus deficiency rarely occurred and were restricted to cows with low serum phosphorus levels grazing poor quality pasture. It is concluded that cause of unthriftiness in many cattle was probably related to malnutrition rather than aphosphorus.

Sub-Category: Mineral Deficiencies
Disease: Cobalt Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komárom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komárom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Cobalt Deficiency
Species Affected: Goats
Region: Antipodes
Country: New Zealand

Reference: Pearson (1987)

Population Studied: 350 goats

Type of Study: Outbreak investigation

Abstract: Cobalt deficiency (white liver disease) was diagnosed as a cause of ill-thrift 15 out of 350 Angora and Angora crossbred goats.

Sub-Category: Mineral Deficiencies
Disease: Cobalt Deficiency
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Mason and McKay (1983)

Population Studied: 24 sheep

Type of Study: Outbreak investigation

Abstract: Cobalt deficiency (white liver disease) was diagnosed as a cause of photosensitisation in 24 sheep in Tasmania.

Sub-Category: Mineral Deficiencies
Disease: Cobalt Deficiency
Species Affected: Cattle and Sheep
Region: Latin America
Country: Brazil

Reference: Tokarnia *et al.* (1971)

Population Studied: Unspecified cattle and sheep populations in different areas of Brazil

Type of Study: Outbreak investigation

Abstract: In the south of the state of Rio de Janeiro a disorder characterised by poor growth rate and production was related to copper deficiency. Seven out of 35 cattle examined had less than 50 ppm in the liver and a further seven less than 100 ppm. Co levels were below 0.12 ppm in three of the cattle. A condition called "mal do roncado" occurs in the north of the state. Copper deficiency was present in three cattle and one sheep examined. Low cobalt levels were detected in two cattle. In the State of Espirito Santa a condition called "toca" occurs. Copper levels were normal in seven cattle examined but cobalt levels were deficient in three. In the north of Santa Catarina state low copper levels were found in 13 out of 14 cattle and in one of two sheep. Cobalt levels were normal. In parts of Mato Grosso animals with "Cara Inchada" were shown to be copper deficient but cobalt levels were normal. In the state of Piaui cattle and sheep suffering from "entrega" had low copper levels in 17 out of 26 examined. In the Territory of Amapa low levels of copper and cobalt were found in five out of six cattle examined.

Sub-Category: Mineral Deficiencies
Disease: Copper Deficiency
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Smith and Coup (1973)

Population Studied: 50 dairy herds in Northland

Type of Study: Survey

Abstract: Copper status was investigated in 50 dairy herds in Northland. Symptoms consistent with copper deficiency were evident, particularly in young animals. 71 blood samples from 16 farms with a history of post-parturient haemoglobinuria had a mean copper content of 0.032 mg/ml and a mean liver content of 8.4 ppm.

Sub-Category: Mineral Deficiencies
Disease: Copper Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komarom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komarom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Copper Deficiency
Species Affected: Cattle and Sheep
Region: Latin America
Country: Brazil

Reference: Tokarnia *et al.* (1971)

Population Studied: Unspecified cattle and sheep populations in different areas of Brazil

Type of Study: Outbreak investigation

Abstract: In the south of the state of Rio de Janeiro a disorder characterised by poor growth rate and production was related to copper deficiency. Seven out of 35 cattle examined had less than 50 ppm in the liver and a further seven less than 100 ppm. Co levels were below 0.12 ppm in three of the cattle. A condition called "mal do roncado" occurs in the north of the state. Copper deficiency was present in three cattle and one sheep examined. Low cobalt levels were detected in two cattle. In the State of Espirito Santa a condition called "toca" occurs. Copper levels were normal in seven cattle examined but cobalt levels were deficient in three. In the north of Santa Catarina state low copper levels were found in 13 out of 14 cattle and in one of two sheep. Cobalt levels were normal. In parts of Mato Grosso animals with "Cara Inchada" were shown to be copper deficient but cobalt levels were normal. In the state of Piaui cattle and sheep suffering from "entrevia" had low copper levels in 17 out of 26 examined. In the Territory of Amapa low levels of copper and cobalt were found in five out of six cattle examined.

Sub-Category: Mineral Deficiencies
Disease: Copper Deficiency
Species Affected: Cattle, Sheep, Goats and Camels
Region: Sub-Saharan Africa
Country: Sudan

Reference: Tartour (1975)

Population Studied: Unspecified livestock populations in Western Sudan

Type of Study: Survey

Abstract: The copper status of cattle, sheep, goats and camels were investigated. The levels in tissues were generally compatible with findings elsewhere but low concentrations were found in the blood and liver of some animals. All areas, except Bahr el Arab, had soil or pasture copper contents which could be interpreted as either critical or deficient for the nutrition of animals.

Sub-Category: Mineral Deficiencies
Disease: Copper Deficiency
Species Affected: Sheep
Region: Western Asia
Country: Turkey

Reference: Urman *et al.* (1971)

Population Studied: Unspecified sheep population on the Black Sea coast

Type of Study: Survey

Abstract: Swayback is a serious problem on the Black Sea coast around Samsun although copper, molybdenum and sulphate concentrations in the local herbage appear to be within normal ranges.

Sub-Category: Mineral Deficiencies
Disease: Iodine Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komarom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komarom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Iodine Deficiency
Species Affected: Goats
Region: Antipodes
Country: New Zealand

Reference: Orr *et al.* (1987)

Population Studied: 48 abortion outbreaks in goats

Type of Study: Outbreak investigation

Abstract: Goitre was identified as a cause in 12% of 48 outbreaks of abortion in goats in 1986 and in 18% of 17 outbreaks in 1987.

Sub-Category: Mineral Deficiencies
Disease: Magnesium Deficiency
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Ellison (1984)

Population Studied: Cattle population of New Zealand

Type of Study: Surveillance

Abstract: Most cases of the disease occur in the seven counties of the country which have yellow-brown loam soils. The incidence of the disease in the spring of 1983 was much higher than the preceding year, apparently as the result of poor grass growth. The economic benefit of providing 76 affected herds with supplementary magnesium was estimated at 1600-4250 NZ dollars per herd.

Sub-Category: Mineral Deficiencies
Disease: Magnesium Deficiency
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Hicks and Pauli (1976)

Population Studied: Unspecified cattle population in the Taranaki region

Type of Study: Survey

Abstract: Chronic oedema of the udder which is unresponsive to therapy is seen in dairy cows within a 30km radius of Eltham, Taranaki. In spring, some cases are associated with a syndrome known as spring anaemia. A survey of 117 cows in summer showed that the oedema-affected cows were hypomagnesaemic but not anaemic.

Sub-Category: Mineral Deficiencies
Disease: Magnesium Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: German Democratic Republic

Reference: Stephan *et al.* (1972)

Population Studied: Unspecified cattle population in the Osterburg/Altmark district

Type of Study: Surveillance

Abstract: Clinically diagnosed cases of grass tetany increased from 0.27% of the cow population under survey in 1964 to 2.09% in 1969. Only 17% of herds remained free of the disease during 1967 to 1969. The highest frequency of the disease within a herd was 9.6%. Slaughter or death ensued in 22.7% of cases.

Sub-Category: Mineral Deficiencies
Disease: Magnesium Deficiency
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Anon (1987a)

Population Studied: 543 calves

Type of Study: Outbreak investigations

Abstract: Between 1978-83 outbreaks of mortalities in calves up to 12 months of age in 117 dairy farms in the municipality of Cantagalo were investigated. 543 dead calves from these outbreaks were examined. Magnesium deficiency was identified as the cause of death in 7% of these cases.

Sub-Category: Mineral Deficiencies
Disease: Manganese Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komárom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komárom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Phosphorus Deficiency
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Botswana

Reference: Cooper (1974)

Population Studied: Unspecified cattle population in Botswana

Type of Study: Survey

Abstract: The mean blood phosphorus content of 919 cattle from 46 areas of Botswana was 4.3 mg %, which was a little above the lower limit of the normal range (4 mg %). In 18 areas the mean value was below 4 mg % and in 33 areas the lower limit of the range fell below 4 mg %. Only 9 % of cattle fed bone meal had levels below 4 mg % compared with 45 % of unsupplemented cattle. It is estimated that 45 % of traditionally farmed cattle in Botswana have hypophosphataemia.

Sub-Category: Mineral Deficiencies
Disease: Phosphorus Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komárom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komárom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Selenium Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Czechoslovakia

Reference: Sterba and Vavra (1987)

Population Studied: 1074 dead calves

Type of Study: Outbreak investigation

Abstract: Death due to the myocardial form of nutritional muscular dystrophy occurred in 8 (3 %) out of 247 dead calves examined in 1985, 49 (11 %) out of 449 dead calves examined in 1986 and 70 (19 %) of 378 dead calves examined in the first half of 1987.

Sub-Category: Mineral Deficiencies
Disease: Selenium Deficiency
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Gabbedy (1971)

Population Studied: Merino sheep on 15 farms in Western Australia

Type of Study: Field trial

Abstract: Between 260-500 merino sheep on each of 15 farms in an area where white muscle disease commonly occurs were observed from six weeks to 19 months of age. Sodium hydrogen selenite (10 mg Se) was administered orally to some sheep at two monthly intervals. Treated and untreated sheep grazed together. A response to weight gain was recorded on four farms; mortality decreased on five farms and fleece weight increased on eight farms. All farms on which responses to selenium were obtained were in areas having an average annual rainfall exceeding 20 inches. On two farms where the average annual rainfall was less than 20 inches selenium supplementation caused depressions in body weight gain and mean fleece weight while mortality increased.

Sub-Category: Mineral Deficiencies
Disease: Selenium Deficiency
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: McDonald (1975)

Population Studied: Merino sheep on a farm in Central Victoria

Type of Study: Field trial

Abstract: Unthriftiness of young sheep in the Strathbogie ranges of Central Victoria has been a problem for 10 to 20 years. White muscle disease had been diagnosed on farms in the area. 80 Merino ewes and lambs were allocated to one of four groups in a trial in which sodium selenite (0.1 mg/kg) was given orally to ewes and/or lambs at marking time and to treated lambs at three monthly intervals thereafter. Selenium treatment of ewes had no effect on subsequent lamb performance. Selenium treatment of lambs reduced mortality to 0% in the treated groups as compared to 17.5% in the untreated groups; body weight gains were 1.9kg higher at both weaning and one year of age in the treated groups; mean fleece weight was 14.4% higher and wool production was increased by 39%.

Sub-Category: Mineral Deficiencies
Disease: Selenium Deficiency
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Smith and Smith (1984)

Population Studied: 600 Perendale ewes

Type of Study: Field experiment

Abstract: Eight treatment groups. Four received: no selenium (Se.), 5 mg. Se. 10 days before mating, 5 mg. Se. 10 days after mating, 5 mg. Se. before and after mating. The second four were treated as above but in addition received zinc oxide (Zn) 100mg/kg body weight twice weekly for 4 weeks starting two weeks before mating. Main differences were between groups receiving Zn plus Se, Se only, Zn only, and neither: Conception rates (%) were: 81, 56, 75 and 60 and embryo mortality (%) was 19, 16, 15 and 29.

Sub-Category: Mineral Deficiencies
Disease: Selenium Deficiency
Species Affected: Sheep
Region: Western Asia
Country: Iran

Reference: Shamna and Sahebi (1976)

Population Studied: 1000 ewes and 100 rams in Northern Iran

Type of Study: Field experiment

Abstract: A high prevalence of muscular dystrophy in sheep occurred in two consecutive years in Northern Iran. 1000 ewes and 100 rams were selected at random and divided into treated and untreated groups. In the treated group, ewes were given an i/m injection of 5 mg Se one month before breeding and a second injection plus 100 mg vitamin E one month before lambing. Lambs were given 5 mg Se at birth. No muscular dystrophy occurred in the treated group where the lambing rate was 95%. In the control group the incidence of muscular dystrophy was 30% and the lambing rate was only 65%.

Sub-Category: Mineral Deficiencies
Disease: Zinc Deficiency
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Smith and Smith (1984)

Population Studied: 600 Perendale ewes

Type of Study: Field experiment

Abstract: Eight treatment groups. Four received: 00 selenium (Se.), 5 mg. Se. 10 days before mating, 5 mg. Se. 10 days after mating, 5 mg. Se. before and after mating. The second four were treated as above but in addition received zinc oxide (Zn) 100mg/kg body weight twice weekly for 4 weeks starting two weeks before mating. Main differences were between groups receiving Zn plus Se, Se only, Zn only, and neither: Conception rates (%) were: 81,56,75 and 60 and embryo mortality (%) was 19,16,15 and 29.

Sub-Category: Mineral Deficiencies
Disease: Zinc Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bodai (1976)

Population Studied: Unspecified cattle population in the county of Komárom

Type of Study: Outbreak investigation

Abstract: Cattle reared in the lowlands of county Komárom in Hungary showed low fertility with high morbidity and mortality losses in newborn calves. Laboratory studies of foodstuffs and blood serum revealed deficiencies of Phosphorus, Copper, Zinc, Manganese, Cobalt and Iodine. Fertility of cattle increased and the incidence of abnormal calves decreased by adding the deficient elements to the diet.

Sub-Category: Mineral Deficiencies
Disease: Zinc Deficiency
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Sudan

Reference: Mahmoud *et al.* (1983)

Population Studied: Single flock of 1837 sheep

Type of Study: Outbreak investigation

Abstract: Suspected zinc deficiency occurred in a flock of sheep at a farm near Khartoum North. 267 mostly unweaned lambs died.

Sub-Category: Vitamin Deficiencies
Disease: Vitamin B (Thiamin) Deficiency
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Bajmócy *et al.* (1986)

Population Studied: Cattle on single farm

Type of Study: Outbreak investigation

Abstract: Cerebro-Cortical Necrosis was diagnosed in 10 of 60 calves (3-6 mth) on a state farm in eastern Hungary. Four affected animals treated with i/v thiamin (10 mg/kg body weight) recovered in 1-3 days.

Sub-Category: Vitamin Deficiencies
Disease: Vitamin E (Alpha-tocopherol) Deficiency
Species Affected: Chicken
Region: Southern Asia
Country: India

Reference: Christopher (1982)

Population Studied: Single flock of 2000 eight week layers

Type of Study: Outbreak investigation

Abstract: Transudative diathesis due to alphatocopherol deficiency affected 1.6 % of 2000 eight week layers.

DISEASES CAUSED BY INORGANIC CHEMICAL AGENTS

Sub-Category: Inorganic Toxicities
Disease: Cadmium Poisoning
Species Affected: Cattle
Region: Eastern Europe
Country: Poland

Reference: Rotkiewicz *et al.* (1979)

Population Studied: 44 bulls

Type of Study: Outbreak Investigation

Abstract: Cadmium poisoning was diagnosed in 44 bulls at an insemination station.

Sub-Category: Inorganic Toxicities
Disease: Cadmium Poisoning
Species Affected: Sheep
Region: Eastern Europe
Country: Yugoslavia

Reference: Petkov *et al.* (1979)

Population Studied: Unspecified number of sheep flocks

Type of Study: Outbreak Investigation

Abstract: Abortion rates in sheep flocks grazing in the vicinity of a lead smelter during 1975 ranged from 10-40%. Lead and cadmium contents of liver (2.31mg%) and kidney (1.44mg%) were much higher than in control animals from another district (0.52 and 0.129 mg% respectively). The sheep were generally in poor condition and lambs born alive were underdeveloped and of low viability.

Sub-Category: Inorganic Toxicities
Disease: Lead Poisoning
Species Affected: Cattle
Region: Eastern Europe
Country: Poland

Reference: Zwolinska-Bartczak *et al.* (1978)

Population Studied: Cattle on eight farms

Type of Study: Outbreak Investigation

Abstract: Data were obtained on 2865 cows at 12 farms within a 13 km radius of a smelter. The content of lead in the blood of cows averaged 0.245 mg/ml for those on the farm nearest to the smelter to 0.046 mg/ml for those from the most distant farm. Calving intervals of 392-416 days were recorded for cows from 3 farms with highest lead levels as against 375 days for cows with the lowest lead levels.

Sub-Category: Inorganic Toxicities
Disease: Lead Poisoning
Species Affected: Sheep
Region: Eastern Europe
Country: Yugoslavia

Reference: Petkov *et al.* (1979)

Population Studied: Unspecified number of sheep flocks

Type of Study: Outbreak Investigation

Abstract: Abortion rates in sheep flocks grazing in the vicinity of a lead smelter during 1975 ranged from 10-40%. Lead and cadmium contents of liver (2.31mg%) and kidney (1.44mg%) were much higher than in control animals from another district (0.52 and 0.129 mg% respectively). The sheep were generally in poor condition and lambs born alive were underdeveloped and of low viability.

Sub-Category: Inorganic Toxicities
Disease: Molybdenum Poisoning
Species Affected: Cattle
Region: Eastern Asia
Country: Japan

Reference: Ogura (1965)

Population Studied: 52 cattle

Type of Study: Outbreak Investigation

Abstract: 52 cattle grazing in the neighbourhood of a molybdenum smelting factory developed diarrhoea and suffered a decrease in milk production and conception rate. The molybdenum level in the blood of these animals was more than 10 times higher than normal.

Sub-Category: Inorganic Toxicities
Disease: Nitrate/Nitrite Poisoning
Species Affected: Cattle
Region: Eastern Europe
Country: Rumania

Reference: Medrea *et al.* (1984)

Population Studied: 188 bovine foetuses

Type of Study: Diagnostic Laboratory Records

Abstract: Nitrate/nitrite poisoning was identified as the sole cause of abortion in 12.2 % of 188 aborted foetuses submitted for laboratory diagnosis. Nitrate/nitrite intoxication in conjunction with fungal infection was the cause in 12.7 % of the cases; in conjunction with *Corynebacterium* infection in 11.1 % of the cases and in conjunction with viral infections in 1.06 % of the cases.

Sub-Category: Inorganic Toxicities
Disease: Sodium Chloride Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Trueman and Calgue (1978)

Population Studied: 60 Brahman cross bullocks

Type of Study: Outbreak investigation

Abstract: Five out of 60 bullocks became ill after being fed a double ration of mineral supplement (4.5 kg salt and 4.5 kg monocalcium and dicalcium phosphate) after not receiving any supplement for several days. One bullock died and three were destroyed. The remaining bullock recovered. A diagnosis of salt poisoning was made on the basis of clinical signs.

Sub-Category: Inorganic Toxicities
Disease: Sulphur Dioxide Poisoning
Species Affected: Cattle
Region: Eastern Europe
Country: Czechoslovakia

Reference: Musek and Hais (1963)

Population Studied: Cattle in Ostrava Region

Type of Study: Longitudinal monitoring

Abstract: A 10 year study was conducted on cattle in Ostrava region which suffers from heavy industrial dust fall and gas emissions containing mostly sulphur dioxide. Weight increases were monitored in 436 animals and milk yield and fat content in 300 animals. In comparison to national standards the animals experienced a decrease in daily milk yield of 9.1 % and a fall in milk fat of 8 %. Daily weight gain was decreased by between 26.4 to 37.5 %.

Sub-Category: Inorganic Toxicities
Disease: Volcanic Dust
Species Affected: Sheep
Region: Western Asia
Country: Turkey

Reference: Yesildere and Alibasoglu (1985)

Population Studied: 83 purchased and 52 slaughter sheep from Central Turkey

Type of Study: Diagnostic and abattoir investigations

Abstract: The post mortem examination of the lungs and lymph nodes of 83 sheep purchased in 1982-1983 in Tüzköy, situated in a volcanic mineral area in central Turkey, revealed pneumoconiosis in 77 (92 %), chronic pleurisy in 44 (53 %), pleural cell proliferation in 17 (20 %) and pleural mesothelioma-like lesions in 3 (3.6 %). Of the 52 sheep examined from the abattoirs of two neighbouring towns (Göleşir and Nevşehir), 14 (27 %) had mild pneumoconiosis lesions.

DISEASES CAUSED BY ORGANIC CHEMICAL AGENTS

Sub-Category: Herbicide Poisoning
Disease: Phenoxo Herbicide Poisoning
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Newell *et al.* (1984)

Population Studied: 20678 female slaughter sheep from 88 farms

Type Of Study: Abattoir investigation

Abstract: 20678 female sheep from 88 farms were examined at slaughter. 125 cases of small-intestinal adenocarcinoma were found in sheep from 61 of the farms. The prevalence rate of individual farm groups varied from 0 to 38 per thousand. Exposure to phenoxy, picolinic acid herbicides or both was associated with significant increases in tumour rate.

Sub-Category: Herbicide Poisoning
Disease: Picolinic Acid Poisoning
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Newell *et al.* (1984)

Population Studied: 20678 female slaughter sheep from 88 farms

Type Of Study: Abattoir investigation

Abstract: 20678 female sheep from 88 farms were examined at slaughter. 125 cases of small-intestinal adenocarcinoma were found in sheep from 61 of the farms. The prevalence rate of individual farm groups varied from 0 to 38 per thousand. Exposure to phenoxy, picolinic acid herbicides or both was associated with significant increases in tumour rate.

Sub-Category: Pesticide Poisoning
Disease: General Pesticide Poisonings
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Anon (1985)

Population Studied: 5000 slaughter cattle

Type of Study: Diagnostic investigation at abattoirs

Abstract: Monitoring of 5000 slaughter cattle for 23 pesticides showed only 1% positive.

Sub-Category: Pesticide Poisoning
Disease: DDT Poisoning
Species Affected: Cattle, Sheep, Pigs
Region: Antipodes
Country: Australia

Reference: Anon (1987)

Population Studied: 6490 cattle, 1228 sheep, 120 pigs

Type of Study: Retrospective study of laboratory records

Abstract: Between 1985-1986, fat samples from the above number of animals were examined for pesticide residues. Samples exceeding the maximum residue levels for DDT were found in two cattle.

Sub-Category: Pesticide Poisoning
Disease: Diazinon Poisoning
Species Affected: Poultry
Region: Sub-Saharan Africa
Country: Kenya

Reference: Keating (1982)

Population Studied: Unspecified cattle, sheep, pig, poultry and dog populations

Type of Study: Retrospective study of Central Veterinary Laboratory records

Abstract: In 1980, poisonous chemicals were implicated in 104 submissions to the Central Veterinary Laboratory. Diazinon was implicated in 10.6% of cases. In 1981 there were 93 submissions where poisonous chemicals were identified. Diazinon was implicated in 16.4% of cases. Poultry were the most commonly affected species.

Sub-Category: Pesticide Poisoning
Disease: Dieldrin Poisoning
Species Affected: Cattle, Sheep, Pigs
Region: Antipodes
Country: Australia

Reference: Anon (1987)

Population Studied: 6490 cattle, 1228 sheep, 120 pigs

Type of Study: Retrospective study of laboratory records

Abstract: Between 1985-1986, fat samples from the above number of animals were examined for pesticide residues. Samples exceeding the maximum residue levels for Dieldrin were found in 16 cattle, one sheep and nine pigs.

Sub-Category: Pesticide Poisoning
Disease: Dioxathion Poisoning
Species Affected: Cattle, Dogs
Region: Sub-Saharan Africa
Country: Kenya

Reference: Keating (1982)

Population Studied: Unspecified cattle, sheep, pig, poultry and dog populations

Type of Study: Retrospective study of Central Veterinary Laboratory records

Abstract: In 1980, poisonous chemicals were implicated in 104 submissions to the Central Veterinary Laboratory. Dioxathion, the main acaricide in use in Kenya, was implicated in 9.6% of total cases. In 1981 there were 93 submissions where poisonous chemicals were identified. Dioxathion was implicated in 59.3% of cases. The species most commonly affected were cattle and dogs.

Sub-Category: Pesticide Poisoning
Disease: Heptachlor Poisoning
Species Affected: Cattle, Sheep, Pigs
Region: Antipodes
Country: Australia

Reference: Anon (1987)

Population Studied: 6490 cattle, 1228 sheep, 120 pigs

Type of Study: Retrospective study of laboratory records

Abstract: Between 1985-1986, fat samples from the above number of animals were examined for pesticide residues. Samples exceeding the maximum residue levels for Heptachlor were found in seven cattle and nine pigs.

Sub-Category: Algae Poisoning
Disease: Blue-Green Algae Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Anon (1985)

Population Studied: 900 cattle

Type of Study: Outbreak investigation

Abstract: 24 of 900 cattle with access to a dam died of blue-green algae toxicity. 30 others had severe liver damage and photosensitisation.

Sub-Category: Algae Poisoning
Disease: Blue-Green Algae Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: McBarron *et al.* (1975)

Population Studied: 500 Corriedale lambs

Type of Study: Outbreak investigation

Abstract: 20 out of 500 Corriedale lambs died after access to water in a dam containing a concentrated bloom of *Anabaena circinalis* in the south east quadrant.

Sub-Category: Fungal Poisoning
Disease: Aflatoxicosis
Species Affected: Rabbits
Region: Southern Asia
Country: India

Reference: Mehrotra and Khanna (1973)

Population Studied: 7000 Angora rabbits on a farm in Himachal Pradesh

Type of Study: Outbreak investigation

Abstract: 4000 out of 7000 rabbits died after consuming pelleted feed contaminated by aflatoxin.

Sub-Category: Fungal Poisoning
Disease: Claviceps (Ergot) Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Jessop *et al.* (1987)

Population Studied: Cattle in 4 dairies and 12 feedlots

Type of Study: Outbreak investigation

Abstract: Between January to July 1986 a disease syndrome thought to be associated through the feeding of ergot (*Claviceps purpurea*) contaminated feed was seen in four dairies and 12 feedlots. Morbidity rates of between 75-100% were seen in all outbreaks and cattle remained affected for up to several months. Virtually no mortalities were observed.

Sub-Category: Fungal Poisoning
Disease: Pithomyces Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Greenwood and Williamson (1985)

Population Studied: 200 six month old lambs

Type of Study: Outbreak investigation

Abstract: 30 out of 200 lambs developed facial eczema. Pasture litter contained high levels of *Pithomyces chartarum* spores.

Sub-Category: Fungal Poisoning
Disease: Pithomyces Poisoning
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Republic of South Africa

Reference: Wet and Erasmus (1984)

Population Studied: Unspecified sheep population in Orange Free State

Type of Study: Outbreak investigation

Abstract: Five outbreaks of suspected facial eczema occurred in sheep in central districts of Orange Free State between June 1982 and January 1984. *Pithomyces chartarum* was isolated from a wheat pasture but no toxicological examinations were made.

Sub-Category: Fungal Poisoning
Disease: Stachybotrys Poisoning
Species Affected: Sheep
Region: Eastern Europe
Country: Hungary

Reference: Harrach (1983)

Population Studied: Single farm outbreak in a flock of 1200 sheep

Type of Study: Outbreak investigation

Abstract: Outbreak occurred in February 1982; 100 of 1200 ewes died. Bedding straw heavily contaminated with *Stachybotrys atra* and Satratoxins G and H isolated. Deaths ceased after removal of bedding. This is first reported outbreak in Hungary.

Sub-Category: Plant Poisoning
Disease: Ammi Poisoning
Species Affected: Sheep
Region: Western Asia
Country: Israel

Reference: Yeruham *et al.* (1988)

Population Studied: Two sheep flocks

Type of Study: Outbreak investigation

Abstract: Reports an outbreak of photosensitisation in sheep in two neighbouring flocks. The first flock consisted of 15 Merino and 10 Awassi ewes. The second flock consisted of 17 Merino and two Merino cross bred ewes. The sheep were fed Vicia hay heavily contaminated with *Ammi majus*. Only the Merino and crossbred Merino ewes were affected.

Sub-Category: Plant Poisoning
Disease: Astragalus Poisoning
Species Affected: Sheep and goats
Region: Western Asia
Country: Iran

Reference: Hosseini *et al.* (1972)

Population Studied: A mixed flock of 1500 sheep and goats near Teheran

Type of Study: Outbreak Investigation

Abstract: Five goats and 58 ewes died suddenly in a mixed flock grazing pasture heavily contaminated with *Astragalus* sp. All the flock were in poor condition. Some ewes aborted and others produced deformed lambs.

Sub-Category: Plant Poisoning
Disease: Bracken Poisoning
Species Affected: Cattle
Region: Latin America
Country: Colombia

Reference: Pena *et al.* (1984)

Population Studied: 3543 cattle on 1068 premises

Type of Study: Survey

Abstract: Examination of 3543 cattle on 1068 premises revealed 41 cases of chronic haematuria. Poisonous plants (including bracken) were considered potential etiological agents.

Sub-Category: Plant Poisoning
Disease: Bracken Poisoning
Species Affected: Cattle
Region: Southern Asia
Country: Sri Lanka

Reference: Bauman (1983)

Population Studied: Cattle on three large scale dairy development farms 1978-1981

Type of Study: Retrospective study of farm records

Abstract: Over the three year period the annual loss in adult cattle due to culling or mortality ranged between 2-15% per year. Bracken fern poisoning accounted for (4%) of total mortalities/culls.

Sub-Category: Plant Poisoning
Disease: *Cenchrus* Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: South Africa

Reference: Heeder *et al.* (1978)

Population Studied: 125 cattle on a farm in the Transvaal

Type of Study: Outbreak investigation

Abstract: Out of 125 cattle grazing paddocks of kikuyu grass (*Pennisetum clandestinum*) or buffalo grass (*Cenchrus ciliaris*) 17 became ill and 76.4% died. Most deaths were in pregnant Hereford cows. Survivors recovered in 4 to 7 days.

Sub-Category: Plant Poisoning
Disease: *Cenchrus* Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: McKenzie *et al.* (1988)

Population Studied: 1900 ewes, 5000 yearlings and 1100 mixed sheep in three separate incidents

Type of Study: Outbreak investigation

Abstract: Three incidents of buffel grass (*Cenchrus ciliaris*) poisoning occurred in sheep in south-western Queensland. In the 1976 incident, over 100 of 1900 ewes died. In the 1986 incident, 90 of 5000 yearlings died and in the 1987 incident 200 of 1100 mixed sheep died.

Sub-Category: Plant Poisoning
Disease: *Crotolaria* Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Zimbabwe

Reference: Andrew (1987)

Population Studied: Unspecified cattle population on a ranch

Type of Study: Outbreak investigation

Abstract: Extremely overgrown hooves were reported in 20% of cattle on a farm. The disorder was attributed to ingestion of *Crotolaria polyperma*.

Sub-Category: Plant Poisoning
Disease: *Cucumis* Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: McKenzie *et al.* (1988)

Population Studied: Cattle on a farm

Type Of Study: Outbreak investigation

Abstract: 26 Hereford heifers died after eating mostly ripe fruit of *Cucumis myriocarpus*.

Sub-Category: Plant Poisoning
Disease: *Dichapetalum* Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Zimbabwe

Reference: Tannock (1975)

Population Studied: Unspecified cattle population north west of Bulawayo.

Type Of Study: Literature review.

Abstract: *Dichapetalum cymosum* accounted for 2/3 of cattle deaths attributed to plant poisoning on regosols north west of Bulawayo where the plant occurs widely.

Sub-Category: Plant Poisoning
Disease: Echium Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Seaman (1987)

Population Studied: Sheep on 193 farms

Type of Study: Outbreak investigation

Abstract: Between 1978-1984 201 incidents involving the death of 2683 sheep were reviewed. There were 834 deaths due to primary pyrrolizidine alkaloid poisoning, of which 203 were due to *Echium plantagineum*, 215 to *Heliotropium europaeum* and 55 to both species. 1849 deaths were due to hepatogenous chronic copper poisoning, of which 787 were due to *Echium*, 310 were due to *Heliotropium* and 227 to both species. Adult crossbred ewes were the class of sheep most commonly affected.

Sub-Category: Plant Poisoning
Disease: Heliotropium Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Seaman (1987)

Population Studied: Sheep on 193 farms

Type of Study: Outbreak investigation

Abstract: Between 1978-1984 201 incidents involving the death of 2683 sheep were reviewed. There were 834 deaths due to primary pyrrolizidine alkaloid poisoning, of which 203 were due to *Echium plantagineum*, 215 to *Heliotropium europaeum* and 55 to both species. 1849 deaths were due to hepatogenous chronic copper poisoning, of which 787 were due to *Echium*, 310 were due to *Heliotropium* and 227 to both species. Adult crossbred ewes were the class of sheep most commonly affected.

Sub-Category: Plant Poisoning
Disease: Kiwifruit Poisoning
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Fraser (1987)

Population Studied: 180 cows

Type of Study: Outbreak investigation

Abstract: In 1986, 58 of 180 cows died following feeding of kiwifruit.

Sub-Category: Plant Poisoning
Disease: Lantana Poisoning
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Sreenivasulu *et al.* (1987)

Population Studied: 40 sheep

Type of Study: Outbreak investigation

Abstract: The symptoms, control and treatment of *Lantana camara* poisoning in sheep are described. 40 cases were recorded between January 1983 and August 1985, of which 10 died. Morbidity and mortality were highest in young animals. Animals with mild to moderate symptoms responded to symptomatic treatment.

Sub-Category: Plant Poisoning
Disease: *Lasiospermum* Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: South Africa

Reference: Thornton (1977)

Population Studied: 93 cattle on a farm in Cape Province

Type of Study: Outbreak investigation

Abstract: Five cattle died and at least 16 others were affected in a herd of 93 cattle eating Ganskweek (*Lasiospermum bispinnatum*). The author concluded that Ganskweek poisoning was one of the most important forms of plant poisoning in sheep and cattle in Graaf-Reinet District.

Sub-Category: Plant Poisoning
Disease: Lucerne poisoning
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Scales *et al.* (1977)

Population Studied: Unspecified ewe population

Type of Study: Field experiment

Abstract: The reproductive performance of ewes mated on either lucerne or ryegrass-white-clover pastures were compared in 1975 and 1976. Phyto-oestrogens were present in lucerne but not ryegrass-clover pastures. In all experiments ewes flushed and mated on lucerne produced fewer lambs, the difference varying between 16% to 38%. Reduced twinning (14 to 32%) accounted for most of this difference. Ovulation rates were 12 to 24% lower in ewes mated on lucerne in 1976.

Sub-Category: Plant Poisoning
Disease: Lucerne poisoning
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Coop (1977)

Population Studied: Unspecified ewe population

Type of Study: Field experiment

Abstract: In two trials in which ewes were grazed on lucerne or on grass pasture for four weeks before mating and for the first three to six weeks after mating, lucerne depressed multiple births by 20% and increased barrenness by 2%.

Sub-Category: Plant Poisoning
Disease: *Marsilea* Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Pritchard *et al.* (1978)

Population Studied: Sheep on 13 farms in New South Wales

Type of Study: Outbreak investigation

Abstract: During 1974-75 there were 2200 deaths in sheep on 13 farms grazing almost pure stands of nardoo fern (*Marsilea* sp.). Two clinical syndromes are described with changes typical of polioencephalomalacia.

Sub-Category: Plant Poisoning
Disease: Melochia Poisoning
Species Affected: Cattle
Region: Latin America
Country: El Salvador

Reference: Palmer and Woodham (1975)

Population Studied: Cattle on three farms

Type of Study: Outbreak investigation

Abstract: Between 40 to 500 cattle died of paralysis and inanition on three farms. The cause was diagnosed as ingestion of *Melochia pyramidata*.

Sub-Category: Plant Poisoning
Disease: Pennisetum Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Wong *et al.* (1987)

Population Studied: 1370 cattle on nine farms in New South Wales

Type of Study: Outbreak investigation

Abstract: In the late summer of 1980, kikuyu grass (*Pennisetum clandestinum*) poisoning was diagnosed on 9 farms in New South Wales. There were 213 deaths among 1370 cattle at risk.

Sub-Category: Plant Poisoning
Disease: Pennisetum Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: South Africa

Reference: Heerder *et al.* (1978)

Population Studied: 125 cattle on a farm in the Transvaal

Type of Study: Outbreak investigation

Abstract: Out of 125 cattle grazing paddocks of kikuyu grass (*Pennisetum clandestinum*) or buffel grass (*Cenchrus ciliaris*) 17 became ill and 76.4% died. Most deaths were in pregnant Hereford cows. Survivors recovered in 4 to 7 days.

Sub-Category: Plant Poisoning
Disease: Pennisetum Poisoning
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: South Africa

Reference: Bryson and Newsholme (1978)

Population Studied: Cattle on a farm in Natal

Type of Study: Outbreak investigation

Abstract: Five out of 24 cows died and two aborted after grazing a paddock of kikuyu grass (*Pennisetum clandestinum*) seven weeks after it was treated with insecticide for army worm.

Sub-Category: Plant Poisoning
Disease: Solanum Poisoning
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Riet-Correa *et al.* (1983)

Population studied: Cattle on 16 farms in the state of Rio Grande do Sul

Type of study: Outbreak investigation

Abstract: Cerebellar disorder suspected due to *Solanum fastigiatum* confirmed by experimental feeding.

Sub-Category: Plant Poisoning
Disease: Sorghum Poisoning
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: McKenzie and McMicking (1977)

Population studied: Cattle on a farm

Type of Study: Outbreak investigation

Abstract: 54 out of 330 breeding cows became ataxic and developed urinary incontinence after grazing on forage sorghum and grain sorghum regrowth. Two animals died and a third was slaughtered. The remaining animals recovered but about 5% developed purulent cystitis.

Sub-Category: Plant Poisoning
Disease: Stypantra Poisoning
Species Affected: Goats
Region: Antipodes
Country: Australia

Reference: Whittington *et al.* (1988)

Population Studied: 427 Angora goats

Type of Study: Outbreak investigation

Abstract: 27 out of 427 Angora goats of mixed age became blind after consuming large amounts of *Stypantra glauca*. A further 200 goats were depressed for several weeks but subsequently recovered.

Sub-Category: Plant Poisoning
Disease: Tribulus Poisoning
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Glastonbury and Boal (1985)

Population Studied: 35 six-month old female goats

Type of Study: Outbreak investigation

Abstract: Photosensitisation occurred in six of 35 six-month female goats grazing an irrigated grass/legume paddock with a prolific growth of *Tribulus terrestris*.

Sub-Category: Snakebite
Disease: Snakebite
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Tanzania

Reference: Mtei (1983)

Population Studied: Cattle in traditional systems in four livestock development centres (LDCs) in Mwanza region

Type of Study: Loogitudinal Monitoring

Abstract: The annual mortality rates in calves due to snakebite in the four livestock development areas were 0.4%, 0.6%, 1.5% and 2.0% respectively. The annual mortality rates in adult cattle due to snakebite 0.0%, 0.2%, 0.6% and 1.2% respectively.

DISEASES CAUSED BY PHYSICAL AGENTS

Sub-Category: Climate
Disease: Hyperthermia
Species Affected: Ducks
Region: Southern Asia
Country: India

Reference: Sharma and Kaushik (1986)

Population Studied: Mortalities io 872 ducks

Type Of Study: Retrospective study of post-mortem records

Abstract: Heat stroke accounted for 2% of deaths in 872 post-mortems carried out on ducks between 1979 and 1983.

Sub-Category: Climate
Disense: Hyperthermia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Stephenson *et al.* (1984)

Population Studied: Three experimental groups of ewes

Type of Study: Experiment

Abstract: The survival rate for lambs of 51 ewes kept in shadeless pens at ambient temperatures of 36°C was 65%, and 84% for lambs in the same pens at ambient temperature of 28°C. In paddocks with shade (180 ewes) and with shade (200 ewes) over three years survival rates were 67 and 51% respectively.

Sub-Category: Climate
Disease: Hyperthermia
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Maru *et al.* (1987)

Population Studied: 5740 lambs of 10 pure breeds and 4 crossbreeds

Type of Study: Longitudinal production and survival study

Abstract: Mortality rate (%) to 90 days averaged 6.39, (Range Nali breed 2.83, Suffolk 18.57). Rate to 2 days was 2.35 (mortality rate to weakness and exposure 1.15), mortality rate 30-90 days 2.04.

Sub-Category: Climate
Disease: Hyperthermia
Species Affected: Sheep
Region: South Asia
Country: India

Reference: Kornel and Vasudevan (1984)

Population Studied: Lambs from 435 mated ewes (1973)

Type of Study: Cohort study

Abstract: Prenatal losses were 1.32%, post-natal to 28 days were 37.5%. 41% of all deaths occurred in the first 12 hrs. 80% of mortalities in the first 7 days were due to starvation or heat stress.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Reece *et al.* (1985)

Population Studied: 19450 dead birds submitted from approximately 1400 broiler flocks in Victoria

Type of Study: Retrospective study of post mortem records

Abstract: Out of 2654 flock diagnoses made, there were 48 diagnoses of chilling.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Alexander (1986)

Population Studied: Unspecified

Type of Study: Review article

Abstract: Losses of lambs under pastoral conditions range from 5 to 70%. Four major non-infectious conditions emerge: birth problems, cold exposure, starvation and birth weight extremes. Preventive strategies for cold exposure and starvation were analyzed; genetic selection for vigour and alertness, easy birth and maternal care of multiples offered the best solutions.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Maxwell (1974)

Population Studied: Lambs in 68 sheep flocks in Western Australia

Type of Study: Survey

Abstract: Lamb mortality was studied in 68 flocks between 1967 and 1969. In 10 flocks that lambed in the spring of 1967, the lamb mortality rate ranged from 17.3 to 42.4%. Flocks on two farms were investigated to study the effects of management. When ewes lambed in paddocks, the mortality rate was 21 and 34% respectively. When ewes lambed in pens the mortality rate was 7.5 and 7.0%.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Obst and Ellis (1977)

Population Studied: Unspecified Merino and Corriedale sheep population on Kangaroo Island Research Station, South Australia

Type of Study: Longitudinal Monitoring

Abstract: Merino and Corriedale ewes lambing during winter were observed. The mortality rate in lambs up to three days of age was 70% when wind speed was 18 km/h and 1.5 mm of rain fell during the first six hours after birth. Survival rates were 90-95% when mean wind speed of 0-8 km/h without rain occurred over the same period.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Gumbrell and Saville (1986)

Population Studied: 21 commercial sheep farms

Type of Study: Survey

Abstract: The study examined over 23000 dead lambs on 21 commercial sheep farms over a five year period representing 9.8% of the total drop on these farms. Lamb losses on individual farms varied from 3% to 20%. 15% of dead lambs showed lesions of starvation and/or exposure. 27% showed lesions of dystocia and starvation/exposure suggesting that dystocia damaged lambs sufficiently to adversely effect their ability to feed and to seek shelter.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Oliveira and Barros (1980)

Population Studied: 2774 Polworth ewes in a flock in Rio Grande do Sul

Type Of Study: Survey

Abstract: Of 200 lambs that died within 10 days of birth, 78.5% died as a consequence of starvation and/or exposure.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Murguta (1988)

Population Studied: 2477 lambs

Type of Study: Retrospective study of farm records

Abstract: Data on 2477 lambs born in Yucatan between 1983-85 were analyzed. Preweaning mortality averaged 16.4% with 38.23% of deaths occurring within one day of birth. Exposure accounted for 33.8% of deaths.

Sub-Category: Climate
Disease: Hypothermia
Species Affected: Sheep
Region: Latin America
Country: Peru

Reference: Ameghino *et al.* (1984)

Population Studied: 603,694 lambs on country's largest sheep farm. 1971-1980

Type of Study: Longitudinal monitoring

Abstract: Mortality rate per 1000 births was: to 3 days 36.94, from 4 to 30 days 5.87. The proportional mortality from different causes was: environment and management determinants (leading to weak lambs and starvation) accounted for 33% of deaths.

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Hedge and Rai (1972)

Population Studied: Unspecified Murrah buffalo population on a coastal farm in Mysore

Type of Study: Retrospective study of farm records

Abstract: The percentages of calves born in January-March, April-June, July-September and October-December was 9.13, 17.68, 41.88 and 64.57% respectively. Average age at first calving was 1970 days, average calving interval was 489 days.

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Dani and Gaikwad (1972)

Population Studied: 155 Murrah buffalo on three farms in Akols

Type of Study: Retrospective study of farm records

Abstract: 90% of all calvings took place between June and December. The peak number of calvings took place in August (rainy season) (22.3, 30.11, and 16.43% of all calvings on the three farms respectively). The lowest number of calvings took place in April (1.79, 0.77 and 1.35%). Buffaloes calving in August had the shortest average calving interval (412 days) and those calving in January and February the longest (535 and 542 days)

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Oliveira Filho *et al.* (1975)

Population Studied: A herd of 633 Nellore cows

Type of Study: Retrospective study of farm records

Abstract: Data on 2738 calvings of 633 Nellore cows were analyzed. The highest percentage of calvings (13.09%) occurred in July and the lowest (0.98%) in January. 63.23% of all calvings occurred during the dry season. The average calving interval was 424 days and the average service period was 133 days. Season had a marked effect on both calving interval and service period with the shortest calving interval (417 days) and service period (126 days) occurring during the dry season as opposed to 434 and 143 days in the wet season.

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Bodisco *et al.* (1976)

Population Studied: Brown Swiss crossbred cows in six herds

Type of Study: Retrospective study of farm records

Abstract: Data on 2238 calving intervals and 2278 service periods of Brown Swiss crossbreds in six herds were analyzed. Calving interval averaged 449.3 days and service interval 154.1 days. Both were significantly affected by parity, herd, year and month of calving and herd x month and year x month interactions.

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Garcia Betancourt *et al.* (1973)

Population Studied: Brown Swiss crossbred cows on three farms in Araure district

Type of Study: Retrospective study of farm records

Abstract: 1948 milk and 1467 reproductive records of Brown Swiss crossbred cows on three farms were analyzed. Calving interval and service period averaged 400.5 and 120.2 days respectively. Both were affected by season with cows calving in September and November showing the best and those between December and May the poorest performance.

Sub-Category: Climate
Disease: Seasonally Related Fertility
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Panda (1972)

Population Studied: 1635 local Bengali and 547 Haryana X Bengal cows in West Bengal

Type of Study: Retrospective study of farm records

Abstract: Data was analyzed on the above cows. The incidence of cows showing oestrous during summer (March-June), winter (November-February) and monsoon (July-October) was 40.8, 34.7 and 24.5% respectively. For local cows the calving rate ranged between 38.7% (September) and 59.1% (April). For crossbreds the calving rate ranged between 36.4% (November) and 64.9% (April).

Sub-Category: Climate
Disease: Seasonally Related Milk Production
Species Affected: Cattle
Region: Latin America
Country: Mexico

Reference: McDowell *et al.* (1976)

Population Studied: Cows from 48 herds

Type of Study: Retrospective study of farm records

Abstract: 17255 lactation records from 48 herds were analyzed. Herd average milk yields ranged from 2620 kg to 7670 kg per year. Year, age, season and their interaction had significant effects on milk yield and accounted for 37% of the total variance.

Sub-Category: Climate
Disease: Seasonally Related Milk Production
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Garcia Betancourt *et al.* (1973)

Population Studied: Brown Swiss crossbred cows on three farms in Araure district

Type of Study: Retrospective study of farm records

Abstract: 1948 milk and 1467 reproductive records of Brown Swiss crossbred cows on three farms were analyzed. Milk yield averaged 2962.6 kg for a 301 day lactation and was significantly affected by farm, season of calving and parity.

Sub-Category: Climate
Disease: Seasonally Related Milk Production
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Rodriguez Voigt *et al.* (1974)

Population Studied: Cows on 31 farms south of Lake Maracaibo

Type of Study: Retrospective study of farm records

Abstract: 1138 milk records and 517 calving intervals of grade Brown Swiss, Holstein-Friesian, zebu crossbred and of nondescript cows from 31 farms for the year 1973 were analyzed. Average lactation length was shortest (268.2 days) for cows calving between December and February and longest (293.8 days) for cows calving between June and August. Average lactation yield was lowest (1433.6 kg) for cows calving between March and May and highest (1587.48 kg) for cows calving between September and November.

Sub-Category: Climate
Disease: Seasonally Related Milk Production
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Dani and Gaikwad (1972)

Population Studied: 155 Murrah buffalo on three farms in Akola

Type of Study: Retrospective study of farm records

Abstract: 90% of all calvings took place between June and December. Buffaloes calving in August (rainy season) had the lowest average milk yield (1464 litres). Buffaloes calving in February (winter) had the highest average milk yield (1809 litres). The longest average dry period (181 days) occurred in buffaloes calving in summer as opposed to the shortest dry period (139 days) for buffaloes calving in the rainy season.

Sub-Category: Climate
Disease: Seasonally Related Milk Production
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Gurnani *et al.* (1973)

Population Studied: Unspecified population of Murrah buffaloes

Type of Study: Retrospective study of farm records

Abstract: Analysis of 886 lactation records for Murrah buffaloes between 1957 and 1971 showed that season of calving had a significant effect on milk yield. Average seasonal milk yields were 1646 kg for winter (November-February), 1582 kg for summer (March-June) and 1393 kg for the rainy season (July-October). Most calvings occurred during the rainy season.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Rose (1978)

Population Studied: Unspecified Merino sheep population in North-West Queensland

Type of Study: Longitudinal Monitoring

Abstract: For the period 1959-64 for spring born lambs the percentage of lambs weighing 2, 2-4, > 4 kg were 6.2, 64.5 and 29.3% respectively. The mortality rates in these categories were 33.7, 14.3 and 3.7%. For the period 1966-70 for autumn born lambs the percentage of lambs weighing 2, 2-4, > 4 kg were 30.0, 65.2 and 4.8% respectively. The mortality rates in these categories were 35.2, 7.9 and 1.6%.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Maxwell (1974)

Population Studied: Lambs in 68 sheep flocks in Western Australia

Type of Study: Survey

Abstract: Lamb mortality was studied in 68 flocks between 1967 and 1969. In 10 flocks that lambed in the spring of 1967, the lamb mortality rate ranged from 17.3 to 42.4%. Flocks on two farms were investigated to study the effects of management. When ewes lambed in paddocks, the mortality rate was 21 and 34% respectively. When ewes lambed in pens the mortality rate was 7.5 and 7.0%.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Latin America
Country: Cuba

Reference: Lima *et al.* (1987)

Population Studied: 658 Pelibuey lambs

Type of Study: Longitudinal survival study

Abstract: Mortality rates to 7 days (%) were singles; 0.07, twins; 1.47, triplets; 9.95, quadruplets; 8.7 and from 8 days to weaning: singles; 2.46, twins; 6.13, triplets; 17.2, quadruplets 26.73. Mortality was higher March-April than June-July or November-December. Parity of dam and sex of lamb did not influence the rate.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Selaive *et al.* (1980)

Population Studied: Unspecified Romney Marsh and Corriedale sheep population in Rio Grande do Sul

Type Of Study: Survey

Abstract: Perinatal mortality rates in lambs born in July, August and September were 28.57, 19.44 and 16.16% respectively.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Coimbra Filho *et al.* (1979)

Population Studied: Unspecified population of Polworth lambs

Type Of Study: Survey

Abstract: Mortality rates from birth to three days in Polworth lambs were 22.2% for lambs born in winter (June to July) and 5.6% for lambs born in spring (September to October). Mortality rates from three days to weaning averaged 80.6% and 30.6% respectively.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Puig *et al.* (1984)

Population Studied: 2149 Polwarth ewes and their lambs 1964-70

Type of Study: Longitudinal survival study

Abstract: Ewes were inseminated during a five month period November-March. The month and year significantly affected conception rate, % ewes lambing rate, litter size and lamb mortality rate. Lamb mortality rate to weaning was by conception month November: 26.17, December: 19.96, January: 21.30, February: 27.41, March: 34.86.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Trejo *et al.* (1988)

Population Studied: 173 lambs of 152 Lincoln longwool ewes

Type of Study: Longitudinal production and survival study

Abstract: Mortality rate (MR) was 27% to 7 days of age. MR was affected by body weight, being 16% for 3.6 to 4.0 kg., 100% for 1.6 kg. Age of ewe, time of lambing, duration of lambing and sex of lamb had no effect on mortality rates.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Narayanaswamy and Yadav (1980)

Population Studied: 320 dead lambs from an experimental flock

Type Of Study: Retrospective study on farm records

Abstract: On a study of 320 lamb deaths, monthly mortality rates ranged from 2.81% in June to 22.5% in March.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Misra *et al.* (1984)

Population Studied: 458 Sirhoni kids and 315 Beetal x Sirhoni kids

Type of Study: Longitudinal study

Abstract: Mortality rate to 12 months was 9.39 and 13.13% respectively. Factors significantly affecting mortality rates were year, season and sex.

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Tomar (1984)

Population Studied: 1971-6 Four breeds: Corriedales, Coimbatories, 1/2 and 3/4 crosses

Type of Study: Longitudinal study

Abstract: Mortality rates (%) in sheep over one year of age by breed as above: 23.64, 8.57, 3.81, 6.84. Significant determinants were: year and sex (all groups), season (pure bred only). Contributions to total mortality (%) were breed, (14.3); year (7.3); sex (1.6) and season (1.1).

Sub-Category: Climate
Disease: Seasonally Related Mortality
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Kenya, Mali, Nigeria, Ethiopia

Reference: Wilson *et al.* (1985)

Population Studied: Traditionally managed sheep

Type of Study: Longitudinal mortality study 6 locations 1972-1983

Abstract: Prewaning mortality ranged from 12.6% (Ethiopia) to 30.2% (Sudan). Season, birth type, parity and management system were all significant determinants.

Sub-Category: Climate
Disease: Seasonally Related Dystocia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: George (1976)

Population Studied: Unspecified number of Dorset Horn Ewes

Type of Study: Longitudinal monitoring

Abstract: The frequency of dystocia was recorded in flocks of Dorset Horn ewes lambing in winter, spring and summer at stocking rates of 8, 12 or 16 ewes per hectare. More ewes experienced difficulties in lambing in winter (35%) and spring (39%) than summer (26%). 36% of perinatal mortality was ascribed to dystocia. Dystocia was more frequent in two year old ewes and foetal size was an important pre-determining factor.

Sub-Category: Solar Radiation
Disease: Squamous Cell Carcinoma
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Gardiner *et al.* (1972)

Population Studied: Unspecified slaughter cattle population in Western Australia

Type of Study: Abattoir Survey

Abstract: Over a three year period, 8.7% of total or partial rejections of carcasses at slaughter-houses in Western Australia were due to cancer eye.

Sub-Category: Solar Radiation
Disease: Squamous Cell Carcinoma
Species Affected: Cattle
Region: North Africa
Country: Azores

Reference: Petisca *et al.* (1987)

Population Studied: 16195 cattle

Type of Study: Survey

Abstract: The disease was diagnosed in 22 (0.13%) out of 16195 cattle examined on the island of Terceira.

Sub-Category: Solar Radiation
Disease: Squamous Cell Carcinoma
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Vandegraaff (1976)

Population Studied: A flock of 385 Merino ewes

Type Of Study: Outbreak investigation

Abstract: Squamous-cell carcinoma of the vulva was observed in 12 out of 385 Merino ewes. It is suggested that this high incidence was due to increased exposure of the perineal region to direct sunlight by short docking of tails.

Sub-Category: Solar Radiation
Disease: Squamous Cell Carcinoma
Species Affected: Sheep
Region: Northern Africa
Country: Azores

Reference: Swan *et al.* (1984)

Population Studied: Slaughter sheep at two abattoirs plus various affected flocks

Type of Study: Abattoir and flock surveys

Abstract: The frequency of the disease in adult sheep slaughtered at two abattoirs was 0.08%. No cases occurred in lambs. Of all adult sheep condemnations before slaughter, 38.5% were due to squamous cell carcinoma. On one affected farm, 4% of ewes were culled in one year for gross lesions of the disease. A further 3.5% of sheep with gross lesions and 25.3% with precursor lesions remained in the flock undetected by the farmer. The frequency of the disease increased with age from 0.43% in five year old ewes to 41% in seven year olds.

Sub-Category: Urogenital System
Disease: General Neoplasia
Species Affected: Cattle
Region: Eastern Asia
Country: China

Reference: Xu *et al.* (1983)

Population Studied: 1392 slaughter cattle in Guizhou Province

Type of Study: Abattoir Investigation

Abstract: Of the 1392 cattle examined 256 (18.7%) had neoplasms of the bladder.

GENETIC DISEASES

Sub-Category: Digestive System
Disease: Atresia Ani
Species Affected: Cattle
Region: Eastern Europe
Country: Czechoslovakia

Reference: Labik *et al.* (1977)

Population Studied: Unspecified cattle population

Type of Study: Outbreak investigation

Abstract: Atresia ani occurred in eight calves sired by three Czech Pied bulls.

Sub-Category: Digestive System
Disease: Umbilical hernia
Species Affected: Cattle
Region: Eastern Europe
Country: Czechoslovakia

Reference: Labik *et al.* (1977)

Population Studied: Unspecified cattle population

Type of Study: Outbreak investigation

Abstract: Umbilical hernia occurred in 50 out of 200 recorded progeny of a Dutch Black Pied bull. A similar condition was seen previously in progeny from another Dutch Black Pied bull. Both bulls had a common ancestor.

Sub-Category: Musculo-Skeletal System
Disease: Brachycephalia
Species Affected: Cattle
Region: Eastern Europe
Country: Poland

Reference: Geringer (1977)

Population Studied: 1.8 million Polish Black and White Lowland calves and 830,000 Red and White Lowland calves.

Type of Study: Retrospective study of production records

Abstract: Between 1968-75 data was recorded on 1.8 million Polish Black and White Lowland calves sired by 506 bulls and 830,000 Polish Red and White Lowland calves sired by 217 bulls. The within breed gene frequency of brachycephalia was 0.032 and 0.039 in the two breeds respectively.

Sub-Category: Musculo-Skeletal System
Disease: Brachygnathia
Species Affected: Cattle
Region: Eastern Europe
Country: USSR

Reference: Ernst *et al.* (1977)

Population Studied: Calves on a dairy farm

Type of Study: Outbreak investigation

Abstract: Within a period of a few months 24 abnormal male and female calves were born at a dairy farm. The abnormalities consisted of brachygnathia and exophthalmia. All the calves were sired by the same bull.

Sub-Category: Musculo-Skeletal System
Disease: Muscle contracture
Species Affected: Cattle
Region: Eastern Europe
Country: USSR

Reference: Emelyanov and Nikitina (1976)

Population Studied: Calves on a collective farm

Type of Study: Retrospective study of production records

Abstract: Between 1936 and 1971 39 abnormal calves were born affected by muscle contracture.

Sub-Category: Musculo-Skeletal System
Disease: Splayleg
Species Affected: Pigs
Region: Antipodes
Country: Australia

Reference: Spicer *et al.* 1986

Population Studied: Single piggyery; 238 litters with 2426 piglets born June-July 1982 and March-April 1983

Type of Study: Longitudinal Monitoring

Abstract: Preparturient loss was 2.9 % and peri-natal mortality was 5.4 %. Birth to weaning mortality was 11.3 %. Splayleg occurred in 5.5 % of piglets born alive and was related to use of Landrace boars. 24 % of splayleg cases died.

Sub-Category: Musculo-Skeletal System
Disease: Syndactyly
Species Affected: Cattle
Region: Eastern Europe
Country: Czechoslovakia

Reference: Labík *et al.* (1977)

Population Studied: Cattle on six farms

Type of Study: Outbreak investigation

Abstract: 11 cases of syndactyly were detected at 6 farms where cows had been inseminated by a Swedish Friesian bull.

Sub-Category: Musculo-Skeletal System
Disease: Vestigial Tail
Species Affected: Cattle
Region: Northern Africa
Country: Egypt

Reference: Zayed and Ghanem (1964)

Population Studied: Calves on an animal breeding station

Type of Study: Retrospective study of farm records

Abstract: Between 1955-61, 21 cases of vestigial tail occurred in black pied calves at Gemmeiza Animal Breeding Station.

Sub-Category: Nervous System
Disease: Brain Oedema
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Jolly (1974)

Population Studied: Nine calves

Type of Study: Outbreak investigation

Abstract: Report on nine cases of a previously undescribed disease in calves characterised by widespread oedema of the grey and white matter of the central nervous system. In all cases the same bull was the sire and grandsire and several of the dams were probably daughters of the bull.

Sub-Category: Nervous System
Disease: Cerebellar Abiotrophy
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Whittington *et al.* (1989)

Population Studied: 74 calves sired by one bull

Type of Study: Outbreak investigation

Abstract: The disease affected 9 of 74 calves sired by a Poll Hereford bull over two calving seasons. 7 calves died. The etiology is thought to be genetic.

Sub-Category: Nervous System
Disease: Cerebellar Hypoplasia
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Finnie and Leaver (1965)

Population Studied: 6 calves

Type of Study: Outbreak investigation

Abstract: Six cases of cerebellar hypoplasia were recorded in newborn shorthorn calves.

Sub-Category: Nervous System
Disease: Cerebellar Hypoplasia
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: O'Sullivan and McPhee (1975)

Population Studied: 16 calves sired by one bull

Type of Study: Outbreak investigation

Abstract: Within two years of the introduction of two Shorthorn bulls from the same stud, 16 calves were born with cerebellar hypoplasia. All affected calves were the progeny of one bull that was related to the other bull.

Sub-Category: Nervous System
Disease: Holoprosencephaly
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Roth *et al.* (1987)

Population Studied: Unspecified population of Border Leicester sheep

Type of Study: Survey

Abstract: The condition is described in Border Leicester lambs. Results of a breeding experiment suggest that the disease is hereditary. A survey suggests that the condition is widespread in Border Leicester sheep.

Sub-Category: Nervous System
Disease: Hyperkinesia
Species Affected: Cattle
Region: Eastern Europe
Country: Rumania

Reference: Adamesteanu *et al.* (1973)

Population Studied: 88 calves on two farms

Type of Study: Outbreak investigation

Abstract: 88 calves (48.6% of the total number) on two farms were found to be suffering from hyperkinesia. A genetic cause of the defect was suspected.

Sub-Category: Nervous System
Disease: Multifocal Symmetrical Encephalopathy
Species Affected: Cattle
Region: Antipodes
Country: Australia and New Zealand

Reference: Harper *et al.* (1989)

Population Studied: Unspecified

Type of Study: Outbreak investigation

Abstract: Report on five cases of the disorder in Simmental calves, three from Australia and two from New Zealand. All cases died. The disorder is thought to be inherited.

Sub-Category: Nervous System
Disease: Spastic Paresis
Species Affected: Cattle
Region: Eastern Europe
Country: German Democratic Republic

Reference: Stolzenburg and Schomuth (1971)

Population Studied: 1907 slaughter bulls, 116 bulls and 62 cows

Type of Study: Study of abattoir records and field studies

Abstract: Of 1907 German Black Pied A.I. bulls slaughtered between 1957-66, 136 had spastic paresis. The average lifespan of 89 affected bulls was 4 years 3 months as compared to 5 years 1 month in 944 normal bulls. The fattening performance of 116 of the progeny of bulls culled for spastic paresis was compared with that of non-carrier animals. There was no difference in average daily weight gain to 400 kg live weight, food conversion or carcass characteristics. 62 daughters of culled bulls showed no difference from controls in age at first calving, body development or milk yield.

Sub-Category: Nervous System
Disease: Spastic Paresis
Species Affected: Cattle
Region: Eastern Europe
Country: Hungary

Reference: Hamori (1976)

Population Studied: 1082 cattle

Type of Study: Retrospective study of production records

Abstract: 1028 descendants of five affected or carrier Hungarian Simmental bulls were studied over three generations. For two affected bulls, 43.47% of their daughters and 31.26% of their second and third generation descendants manifested the syndrome. For the three carrier bulls, 28.12% of their daughters, 14.0% of the second generation and 6.6% of the third generation manifested the syndrome.

Sub-Category: Nervous System
Disease: Spinal Ataxia
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: South Africa

Reference: Von Maltitz *et al.* (1969)

Population Studied: Herd of 80 cattle

Type of Study: Outbreak investigation

Abstract: Spinal ataxia occurred in five young animals in a herd of 80 inbred Africander and Africander cross cattle.

Sub-Category: Skin and Connective Tissue
Disease: Anophthalmia
Species Affected: Cattle
Region: Northern Africa
Country: Egypt

Reference: Zayed and Ghanem (1964)

Population Studied: Calves on a dairy farm

Type of Study: Retrospective study of farm records

Abstract: Between 1955-61, 11 cases of anophthalmia occurred in black pied calves at Gemmeiza Animal Breeding Station.

Sub-Category: Skin and Connective Tissue
Disease: Exophthalmia
Species Affected: Cattle
Region: Eastern Europe
Country: USSR

Reference: Ernst *et al.* (1977)

Population Studied: Calves on a dairy farm

Type of Study: Outbreak investigation

Abstract: Within a period of a few months, 24 abnormal male and female calves were born at a dairy farm. The abnormalities consisted of brachygnathia and exophthalmia. All the calves were sired by the same bull.

Sub-Category: Skin and Connective Tissue
Disease: Hereditary Blindness
Species Affected: Cattle
Region: Eastern Europe
Country: USSR

Reference: Goldman *et al.* (1974)

Population Studied: Calves on a dairy farm

Type of Study: Outbreak investigation

Abstract: Between 1965-68, 29 out of 80 Gorbato Red calves sired by two particular bulls were born blind.

Sub-Category: Skin and Connective Tissue
Disease: Microphthalmia
Species Affected: Cattle
Region: Latin America
Country: Argentina

Reference: Renner (1977)

Population Studied: 170 calves

Type of Study: Outbreak investigation

Abstract: 7 out of 170 calves born in a beef herd had microphthalmia. All the affected calves were sired by the same bull. After the culling of the bull no further cases occurred.

Sub-Category: Skin and Connective Tissue
Disease: Dermatitis vegetans
Species Affected: Pigs
Region: Eastern Asia
Country: China

Reference: Pin *et al.* (1987)

Population Studied: Unspecified population of pigs

Type of Study: Outbreak investigation

Abstract: First report of the condition in China. The incidence ranged between 6.26 to 26.2% and caused highest mortality between two to five weeks of age.

Sub-Category: Skin and Connective Tissue
Disease: Dermatosia Vegetans
Species Affected: Pigs
Region: Antipodes
Country: Australia

Reference: Webb and Bourke (1987)

Population Studied: 11 piglets

Type of Study: Outbreak investigation

Abstract: Four of 11 piglets born to a Landrace sire and a Landrace x Large White sow were affected with dermatosis vegetans. The Landrace sire was also the sire of the sow.

Sub-Category: Skin and Connective Tissue
Disease: Harelip
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Fonseca *et al.* (1977)

Population Studied: Progeny of 17 Gir cows

Type of Study: Outbreak investigation

Abstract: Harelip was found in 21 out of 62 calves born to 17 Gir cows.

DISEASES OF UNKNOWN ETIOLOGY

Sub-Category: General Systemic Disease
Disease: Amyloidosis
Species Affected: Ducks
Region: Eastern Asia
Country: Taiwan

Reference: Liu (1985)

Population Studied: 8206 slaughter ducks

Type of Study: Abattoir Investigation

Abstract: Between January 1979 and December 1981 examination of 8206 slaughtered ducks revealed amyloidosis in 712 of 857 (83%) Pekin ducks, 2923 of 3880 (46%) Kaiya ducks, 1551 of 3391 (46%) Chinese Common ducks and none of 78 Muscovy ducks.

Sub-Category: General Systemic Disease
Disease: Non-Specific Runting
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Reece *et al.* (1985)

Population Studied: 19450 dead birds submitted from approximately 1400 broiler flocks in Victoria

Type of Study: Retrospective study of post mortem records

Abstract: Out of 2654 flock diagnoses made, there were 56 diagnoses of non-specific runting.

Sub-Category: General Systemic Disease
Disease: Cara Inchada
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Conrad *et al.* (1984)

Population Studied: Unspecified cattle populations in the central region of Brazil

Type Of Study: Review article

Abstract: A periodontal disease affecting between 10% and 20% of young cattle in certain regions of central Brazil. Disease is thought to be due to copper and zinc deficiencies complicated by copper, molybdenum and sulphur inter-relationships.

Sub-Category: General Systemic Disease
Disease: Secadera
Species Affected: Cattle
Region: Latin America
Country: Colombia

Reference: Corrier *et al.* (1978)

Population Studied: Cattle on 37 ranches in the eastern plains of Colombia

Type Of Study: Survey

Abstract: A wasting disease, primarily of lactating cattle, prevalent in the eastern plains of Colombia. Over a two year period 51% of the 37 ranches surveyed reported cases of the disease. The total number of cases reported was 557 out of an estimated population at risk of 22628 cattle. Seven of the ranches reported 20 or more cases. Case fatality rates were as high as 30%. The disease is thought to be due to a combination of nutritional (mineral) deficiencies with intercurrent infectious disease.

Sub-Category: Digestive System
Disease: Necrotic Stomatitis/Nephrosis Syndrome
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Zimbabwe

Reference: Hopkins (1987)

Population Studied: Unspecified cattle population in the Harare and Marondera areas

Type Of Study: Unspecified

Abstract: A disease of unknown aetiology characterised by necrotic stomatitis and uraemia has been responsible for the death of many hundreds of cattle in Zimbabwe since its first recognition in 1966. It occurs in the rainy season, between January and March in areas above an altitude of 1480 meters. Up to 10% of a herd may be affected. The case fatality rate is at least 75% after an illness lasting 1-21 days.

Sub-Category: Digestive System
Disease: Intestinal Torsion and Gastric Ulcer
Species Affected: Pig
Region: Eastern Asia
Country: Taiwan

Reference: Hsu *et al.* (1985)

Population Studied: Three large scale closed intensive farms containing 3575 sows, 61109 piglets and 543000 growing pigs

Type of study: Two year survey

Abstract: Out of 538 dead growing pigs, 33.1% of deaths were due to gastrointestinal disease. Intestinal torsion accounted for 59.6% of these cases. Of 614 dead finishing pigs, 29% of deaths were due to gastro-intestinal disease. Gastric ulcer accounted for 31.5% of these cases.

Sub-Category: Digestive System
Disease: Fatty Liver and Kidney Syndrome
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Reece *et al.*

Population Studied: 19450 dead birds submitted from approximately 1400 broiler flocks in Victoria

Type of study: Retrospective study of post mortem records

Abstract: Out of 2654 flock diagnoses made, there were 100 diagnoses of fatty liver and kidney syndrome.

Sub-Category: Circulatory System
Disease: Ascites Syndrome
Species Affected: Chickens
Region: Latin America
Country: Mexico

Reference: Coello *et al.* (1985)

Population Studied: Broiler flocks

Type Of Study: Outbreak investigations

Abstract: Ascites syndrome is a major cause of mortality in broiler flocks in Mexico with losses averaging 15% per affected flock and an estimated annual cost of \$40 million per year. The disease is thought to be associated with toxic feeds.

Sub-Category: Circulatory System
Disease: Hydropericardium
Species Affected: Chickens
Region: Western Asia
Country: Pakistan

Reference: Qureshi (1988)

Population Studied: Unspecified broiler chicken population

Type of Study: Outbreak investigation

Abstract: Report of a disease syndrome causing high mortality in broiler chickens during the first half of 1988. Main lesions appeared in the heart as hydropericardium and the kidneys were enlarged with urate deposited in the tubules and ureters.

Sub-Category: Circulatory System
Disease: Sudden Death Syndrome
Species Affected: Chickens
Region: Antipodes
Country: Australia

Reference: Hopkinson *et al.* (1983)

Population Studied: Affected flocks in Western Australia

Type of Study: Outbreak investigation

Abstract: The disease first became apparent in September 1980. At that time mortality rates in affected flocks ranged between 0.5 - 3.0% per week. Deaths triggered by feeding time, stress including hot weather and characterised by cardiac hypertrophy and excessive pericardial fluid.

Sub-Category: Nervous System
Disease: Cerebrospinal Poliomalacia
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Ghana

Reference: Bonniwell and Barlow (1985)

Population Studied: Sheep on eight properties

Type of Study: Outbreak investigation

Abstract: The condition was encountered on eight properties between 1876 and 1981. It was responsible for losses of up to 72% of the sheep stock in some years.

Sub-Category: Nervous System
Disease: Focal Symmetrical Encephalomalacia
Species Affected: Sheep
Region: Eastern Europe
Country: Hungary

Reference: Glavits *et al.* (1988)

Population Studied: Two sheep flocks

Type of Study: Outbreak investigation

Abstract: Reports on two outbreaks of the condition. The first in six fattening lambs in a flock of 850 Merino x Plevan crossbred ewes and 650 lambs. The second in ten younger animals in a flock of 450 Merino ewes.

Sub-Category: Nervous System
Disease: Necrotic Encephalitis
Species Affected: Cattle
Region: Latin America
Country: Argentina

Reference: Dubarry *et al.* (1984)

Population Studied: 3000 cattle on nine properties

Type Of Study: Outbreak investigation

Abstract: A nervous disease of cattle occurred on nine properties between 1980 and 1984. Morbidity rates ranged from 1 to 30%. Mortality occurred in some 160 out of the 3000 cattle on the premises.

Sub-Category: Respiratory System
Disease: Respiratory Distress Syndrome
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Bhardwaj and Rahka (1984)

Population Studied: 160 buffaloes in four villages

Type Of Study: Outbreak investigation

Abstract: The disease affected 106 out of 160 buffaloes in four villages of Haryana State. Most cases were in animals between five to eight years old and two-thirds were females in early lactation.

Sub-Category: Uro-Genital System
Disease: Breeding Disturbance Syndrome
Species Affected: Pigs
Region: Eastern Asia
Country: China

Reference: Yang *et al.* (1987)

Population Studied: 8235 sows

Type Of Study: Survey; methodology unspecified

Abstract: A survey of 19 pig farms in Hubei Province found 3390 cases of Breeding Disturbance Syndrome in 8235 sows. Abortions were recorded in 162 sows, infertility in 501, stillbirths in 1723 and weak piglets in 542. 443 sows produced litters of less than 5 piglets each. 10849 piglets were lost out of 84392 born.

Sub-Category: Uro-Genital System
Disease: Necrotic Stomatitis/Nephrosis Syndrome
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Zimbabwe

Reference: Hopkins (1987)

Population Studied: Unspecified cattle population in the Harare and Marondera areas

Type Of Study: Unspecified

Abstract: A disease of unknown aetiology characterised by necrotic stomatitis and uraemia has been responsible for the death of many hundreds of cattle in Zimbabwe since its first recognition in 1966. It occurs in the rainy season, between January and March in areas above an altitude of 1480 meters. Up to 10% of a herd may be affected. The case fatality rate is at least 75% after an illness lasting 1 - 21 days.

Sub-Category: Uro-Genital System
Disease: Urolithiasis
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: McIntosh *et al.* (1974)

Population Studied: Unspecified population of sheep in South Australia

Type Of Study: Survey

Abstract: Overall the prevalence of urolithiasis is low but in some areas it causes heavy losses. Uroliths were collected from 93 field outbreaks. On analysis 47% contained both calcium oxalate and silica, 75% contained at least one of these substances, 13% were composed of calcium carbonate and 11% consisted of organic matter. It is concluded that dietary and management factors could be important in the onset and development of outbreaks.

Sub-Category: Uro-Genital System
Disease: Urolithiasis
Species Affected: Cattle
Region: Eastern Asia
Country: Japan

Reference: Tsuchiya and Sato (1988)

Population Studied: 35450 cattle

Type Of Study: Survey; methodology unspecified

Abstract: Over a period of 57 months urolithiasis was found in 1.2% of 15 851 Japanese black cattle and in 0.34% of 19599 Holstein cattle in Kanagawa province. The calculi were mainly magnesium ammonium phosphate.

NON-INFECTIOUS MULTIFACTORIAL CAUSES OF PRODUCTION LOSS

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Cattle
Region: Northern Africa
Country: Tunisia

Reference: Zrelli *et al.* (1988)

Population Studied: Cattle population on three dairy farms

Type Of Study: Survey

Abstract: A two year survey of 3 dairy farms revealed calf losses of 18.8% in the first year and 23.6% in the second. 20.5% of these losses were due to stillbirths. Inadequate nutrition of dams late in pregnancy was thought to have been a major contributory factor.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Alexander (1986)

Population Studied: Unspecified

Type of Study: Review article

Abstract: Losses of lambs under pastoral conditions range from 5 to 70%. Four major non-infectious conditions emerge: birth problems, cold exposure, starvation and birth weight extremes. Preventive strategies for cold exposure and starvation were analyzed: genetic selection for vigour and alertness, easy birth and maternal care of multiples offered the best solutions.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Kleemann *et al.* (1986)

Population Studied: 286 Merino cross ewes and their offspring

Type of Study: Field experiment

Abstract: Ewes were fed different levels of dietary supplement. Lamb mortality was: singles 29%, twins 47%, triplets 66% and quadruplets 83%. The level of supplementation affected the mortality rates. Prolonged birth was the commonest identified cause of death (19.2 - 33.3%). Preparturient loss was 2.9% and peri-natal mortality was 5.4%.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Rose (1978)

Population Studied: Unspecified Merino sheep population in North-West Queensland

Type of Study: Longitudinal Monitoring

Abstract: For the period 1959-64 for spring born lambs the percentage of lambs weighing 2, 2-4, > 4 kg were 6.2, 64.5 and 29.3% respectively. The mortality rates in these categories were 33.7, 14.3 and 3.7%. For the period 1966-70 for autumn born lambs the percentage of lambs weighing 2, 2-4, > 4 kg were 30.0, 65.2 and 4.8% respectively. The mortality rates in these categories were 35.2, 7.9 and 1.6%.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Obst and Ellis (1977)

Population Studied: Unspecified Merino and Corriedale sheep population on Kangaroo Island, South Australia

Type of Study: Longitudinal Monitoring

Abstract: Merino and Corriedale ewes lambing during winter were observed. The mortality rate in lambs up to three days of age was 70% when wind speed was 18 km/h and 1.5 mm of rain fell during the first six hours after birth. Survival rates were 90-95% when mean wind speed of 0-8 km/h without rain occurred over the same period.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Maxwell (1974)

Population Studied: Lambs in 68 sheep flocks in Western Australia

Type of Study: Survey

Abstract: Lamb mortality was studied in 68 flocks between 1967 and 1969. In 10 flocks that lambed in the spring of 1967, the lamb mortality rate ranged from 17.3 to 42.4%. Out of 1869 dead lambs studied, 15% of deaths occurred before birth, 14% during normal births, 14% during difficult births, 7% immediately after birth, 23% soon after birth and 27% some time after birth. Flocks on two farms were investigated to study the effects of management. When ewes lambed in paddocks, the mortality rate was 21 and 34% respectively. When ewes lambed in pens the mortality rate was 7.5 and 7.0%.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Hinch *et al.* (1985)

Population Studied: Booroola ewes: three flocks

Type of Study: Longitudinal monitoring

Abstract: The effects of year, weight of ewes at joining, litter size and wastage during pregnancy (ovulation rate minus litter size) on lamb birth weights were examined. Average ovulation rates were 2.2 and litter size was 1.8. The largest proportion of variation in birth weight was associated with litter size (71-83% $P = 0.01$). Other factors were year difference (6.7-11.8% $p = 0.001$), ewe joining weight (0.9-4.4% $p = 0.001$) and wastage during pregnancy (1.1-3.5% $p = 0.01$). High ovulation rates resulting in prenatal death resulted in lower birth weights. The loss was estimated: 8% of lambs lost 0.3 kg.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Hinch *et al.* (1984)

Population Studied: Booroola Merino flocks on two research stations 1975-1981

Type of study: Longitudinal monitoring

Abstract: On the two stations mean lambing percentages were 196 and 176. Mortality rates (%) were singles 9.0, twins 20.8, triplets 41.3, quadruplets 49.1. Determinants of mortality were examined. Birth weight was most important and the effect of year and birth rank were confounded with weight. The ewe age effect was completely explained by birth weight differences. Even at a given weight lambs from litters of three or more had a higher mortality rate.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Gumbrell and Saville (1986)

Population Studied: 21 commercial sheep farms

Type of Study: Longitudinal Monitoring

Abstract: The study examined over 23000 dead lambs on 21 commercial sheep farms over a five year period representing 9.8% of the total drop on these farms. Lamb losses on individual farms varied from 3% to 20%. 47% of dead lambs showed lesions of dystocia without sign of other contributing causes. 27% showed lesions of dystocia and starvation/exposure suggesting that dystocia damaged lambs sufficiently to adversely effect their ability to feed and to seek shelter.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Eastern Europe
Country: Poland

Reference: Jankowski *et al.* (1988)

Population Studied: 4256 corriedale lambs

Type of Study: Longitudinal survival study

Abstract: Survival of lambs from 51 sires was significantly affected by birth type, sex, year of birth and sire. Average mortality rates (%) were: singles 11.0; twins 12.6, triplets 21.4 and quadruplets 34.1.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Eastern Europe
Country: Poland

Reference: Lipecka and Gruszecki (1984)

Population Studied: 2235 mated ewes

Type of Study: 11 year survival and production study

Abstract: Four groups were studied in relation to the transferring gene, homo or heterozygous ewes were mated to either homo or heterozygous rams. Lambing rate (%) was 155.6, 153.1, 130.4, 128.1. Stillbirths (%) was 18.4, 15.4, 7.5, 9.1.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Eastern Europe
Country: USSR

Reference: Kovnerev and Smirnov (1988)

Population Studied: 1620 Romanov ewes

Type of Study: Field experiment

Abstract: Ewes were in three groups: slatted floors, deep litter (two groups). Mortality rates (%) in lambs to five months were 10.8, 6.8 and 6.3 respectively.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Selaive *et al.* (1980)

Population Studied: Unspecified Romney Marsh and Corriedale sheep population in Rio Grande do Sul.

Type Of Study: Survey

Abstract: Perinatal mortality rates in lambs born in July, August and September were 28.57, 19.44 and 16.16% respectively.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Oliveira and Barros (1980)

Population Studied: 2774 Polworth ewes in a flock in Rio Grande do Sul

Type Of Study: Survey

Abstract: Of 200 lambs that died within 10 days of birth, 78.5% died of starvation or due to exposure, 21% as a consequence of dystocia, 4.5% to predators, 2.5% due to trauma and 2.5% were stillborn.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Coimbra Filho *et al.* (1979)

Population Studied: Unspecified population of Polworth lambs

Type Of Study: Survey

Abstract: Mortality rates from birth to three days in Polworth lambs were 22.2% for lambs born in winter (June to July) and 5.6% for lambs born in spring (September to October). Mortality rates from three days to weaning averaged 80.6% and 30.6% respectively.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Puig *et al.* (1984)

Population Studied: 2149 Polwarth ewes and their lambs 1964-70

Type of Study: Field experiment

Abstract: Ewes were inseminated during a five month period November-March. The month and year significantly affected conception rate, % ewes lambing rate, litter size and lamb mortality rate. Lamb mortality rate to weaning was by conception month November: 26.17, December: 19.96, January: 21.30, February: 27.41, March: 34.86.

Sub-Category: Mortalities Of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Chile

Reference: Clara (1977)

Population Studied: 1581 Corriedale ewes on the Magallanes

Type Of Study: Retrospective study of farm records

Abstract: Data on 947 adult and 634 two-tooth Corriedale ewes grazed on either tussock or scrub pasture showed 3.87% stillbirths on tussock and 3.8% on scrub pasture. Mortality in lambs under three days old was 17.24 and 14.92%. Mortality rates from three days to weaning were 4.08 and 4.61%. Weaning rates were 61.71 and 69.41 lambs per 100 adult ewes and 51.10 and 52.5 per 100 per young female for the two types of pasture.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Cuba

Reference: Lima *et al.* (1987)

Population Studied: 658 Pelibuey lambs

Type of Study: Longitudinal monitoring

Abstract: Mortality rates to 7 days (%) were singles: 0.07, twins: 1.47, triplets: 9.95, quadruplets: 8.7 and from 8 days to weaning: singles: 2.46, twins: 6.13, triplets: 17.2, quadruplets 26.73. Mortality was higher in March-April than June-July or November-December. Parity of dam and sex of lamb did not influence the rate.

Sub-Category: Mortalities Of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Trejo and Lucas (1988)

Population Studied: 1043 ewes in three flocks

Type of Study: Retrospective study of farm records

Abstract: Data on 1043 imported Suffolk ewes in three flocks were analyzed. Overall lamb mortalities from birth to one week of age, from one week to one month and from one month to weaning were 12.8%, 4.4% and 7.8% respectively. Preweaning mortality rates in the three flocks were 26.8%, 27.1% and 22.3%. Stillbirths accounted for 13.0%, 29.0% and 15.0% of deaths in the three flocks.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Trejo *et al.* (1988)

Population Studied: 173 lambs of 152 Lincoln longwool ewes

Type of Study: Retrospective study of farm records

Abstract: Mortality rate (MR) was 27% to 7 days of age. MR was affected by body weight, being 16% for 3.6 to 4.0 kg., 100% for 1.6 kg. Age of ewe, time of lambing, duration of lambing and sex of lamb had no effect.

Sub-Category: Mortalities Of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Latin America
Country: Peru

Reference: Ameghino *et al.* (1984)

Population Studied: Sheep population on a large ranch (estimated annual population of 177,000)

Type of Study: Longitudinal monitoring

Abstract: Between 1971 and 1980 a total of 603694 lamb births were recorded. Mortality during the first three days of life was 36.94/1000 births and for the period from 4 to 30 days 5.87/1000. The principal non-infectious causes of mortality were weak lamb syndrome (17.5% of all deaths), accidents/injuries (14.2%), stillbirths (13.4%), starvation (7.8%) and predation (7.2%).

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Botswana

Reference: Anon (1987b)

Population Studied: Tswana sheep at two research stations, number not stated

Type of Study: Longitudinal monitoring

Abstract: Lamb mortality was 7.1 and 10.95 respectively.

Sub-Category: Mortalities Of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Ethiopia

Reference: Njau *et al.* (1988)

Population Studied: Six flocks

Type Of Study: Longitudinal monitoring

Abstract: Reports on 1025 deaths from six flocks over a four year period. Annual mortality rates were 20.8 %, 16 %, 43 % and 72.2 % respectively. Perinatal mortality accounted for 18.1 % of the total mortality.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Kenya, Mali, Nigeria, Ethiopia

Reference: Wilson *et al.* (1985)

Population Studied: Traditionally managed sheep in six locations

Type of Study: Longitudinal monitoring

Abstract: Between 1972 and 1983, preweaning mortality ranged from 12.6 % (Ethiopia) to 30.2 % (Sudan). Season, birth type, parity and management system were all significant determinants.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Sub-Saharan Africa
Country: Togo

Reference: Vlaenderen (1984)

Population Studied: 900 African Dwarf Sheep on 25 farms

Type of Study: Longitudinal monitoring

Abstract: Mortality rates (%) in different systems were: traditional 14, improved traditional 16, extensive collective 5.5, extensive individual 4.6, intensive 1.6.

Overall survival rate (SR) to 7 days was 89.98 %. SR of lambs with various coat types was very fine: 38.46 (n = 13), fine 40.00 (n = 75), medium 93.98 (n = 216) coarse 98.41 (n = 378), very coarse 93.81 (n = 97).

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
 Species Affected: Sheep
 Region: Sub-Saharan Africa
 Country: Republic of South Africa

Reference: Meaker and Niekerk (1977)

Population Studied: Lambs from 50 Merino ewes

Type Of Study: Experimental study

Abstract: 50 pregnant Merino ewes were allotted to two planes of nutrition for the last six weeks of gestation. Neonatal mortality in single and multiple lambs for ewes on the low plane of nutrition was 18.2 and 26.7% respectively as compared to 6.7 and 10.0% for lambs from ewes on the high plane.

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-weaning Mortalities
 Species Affected: Sheep
 Region: Sub-Saharan Africa
 Country: Republic of South Africa

Reference: Cloete *et al.* (1987)

Population Studied: 1483 Dorper lambs

Type of Study: Longitudinal monitoring

Abstract: Survival to weaning was 91% and no determinants were identified.

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-weaning Mortalities
 Species Affected: Sheep
 Region: Southern Asia
 Country: India

Reference: Kornel and Vasudevan (1984)

Population Studied: Lambs from 435 mated ewes (1973)

Type of Study: Longitudinal monitoring

Abstract: Prenatal losses were 1.32%, post-natal to 28 days were 37.5%. Mortality to 7 days from starvation or heat stress was 80%, 41% of deaths were in the first 12 hours. Mortality from 7-28 days was dependent on birth weight: 84.7% of lambs weighing 1.4 kg. died, 9.8% of those in range 4-4.4 kg died.

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-weaning Mortalities
 Species Affected: Sheep
 Region: Southern Asia
 Country: India

Reference: Misra *et al.* (1984)

Population Studied: 458 Sirhoni kids and 315 Beetal x Sirhoni kids

Type of Study: Longitudinal monitoring

Abstract: Mortality rate (MR) to 12 months 9.39 and 13.13% respectively. Factors significantly affecting were year, season and sex (MR 15.97 for males and 7.4% females).

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Tomar (1984)

Population Studied: 1971-6 Four breeds: Corriedales, Coimbatories, 1/2 and 3/4 crosses.

Type of Study: Longitudinal Study

Abstract: Mortality rates (%) in sheep over one year of age by breed as above: 23.64, 8.57, 3.81, 6.84. Significant determinants were: year and sex (all groups), season (pure bred only). Contributions to total mortality (%) were breed, (14.3); year (7.3); sex (1.6) and season (1.1).

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Panisup and Kaira (1977)

Population Studied: 5277 lambings on two farms in Hissar

Type Of Study: Retrospective study of farm records

Abstract: Out of 5277 births on two farms in four years, 0.3% were stillbirths. Mortality rate in lambs up to one month old was 8.8% and up to six months 17.6%.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Maru *et al.* (1987)

Population Studied: 5740 lambs of 10 pure breeds and 4 crossbreeds

Type of Study: Longitudinal monitoring

Abstract: Mortality rate (%) to 90 days averaged 6.39, (Range Nali breed 2.83, Suffolk 18.57). High mortality probably due to multiple births. Rate to 2 days was 2.35 (mortality rate to weakness and exposure 1.15), mortality rate 30-90 days 2.04.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Singh *et al.* (1987)

Population Studied: 3511 lambs born over 7 year period

Type of Study: Longitudinal monitoring

Abstract: For the breeds Chokla, Nali, Soviet Merino x Nali and Rambouillet x Chokla mortality rate (%) to weaning of male and female respectively were 20.19, 21.66; 19.53, 21.8; 14.75, 11.16; 17.06, 13.38. Breed differences were significant, sex differences were not.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities.
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Narayanaswamy and Yadav (1980)

Population Studied: 320 dead lambs from an experimental flock

Type Of Study: Retrospective study on farm records

Abstract: 54% of deaths in 320 dead lambs occurred between birth and weaning. 44.82% of the mortalities occurred in lambs weighing less than 1.3 kg. Monthly mortality rates ranged from 2.81% in June to 22.5% in March.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-Weaning Mortalities.
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Krishna *et al.* (1979)

Population Studied: 1373 lambs and 536 kids

Type Of Study: Retrospective study on farm records

Abstract: In a four year study of 1373 lambs and 536 kids, the incidence of foetal deaths was 7.42 and 1.3% respectively. Neonatal mortality rates were 27.09 and 24.62% respectively. 60.54 and 53.95% of deaths were in the first week of life.

Sub-Category: Mortalities of Young Stock
Disease: Perinatal, Neonatal and Pre-weaning Mortalities
Species Affected: Sheep
Region: South-East Asia
Country: Indonesia

Reference: Tiesnamarti *et al.* (1985)

Population Studied: 220 lambs born Oct 1883 at research institute

Type of Study: Longitudinal monitoring

Abstract: Dams were Javanese thin-tailed from Garut and Semarang and fat-tailed sheep. Mortality at birth was 9.1% and to weaning was 13.0%. Both rates were significantly affected by breed and litter size.

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
 Species Affected: Pigs
 Region: Antipodes
 Country: Australia

Reference: Spicer *et al.* 1986

Population Studied: Single piggery; 238 litters with 2426 piglets born June-July 1982 and March-April 1983

Type of Study: Longitudinal monitoring

Abstract: Preparturient loss was 2.9% and peri-natal mortality was 5.4%. Birth to weaning mortality was 11.3%. Among piglets born alive, cause specific mortality rates for the period were overlying (2.1%), diarrhoea (1.7%), anaemia (1.2%), savaging (1.1%) and losses of small weak piglets (0.9%). Most deaths and still births were associated with below average birth weight and two thirds of all deaths of liveborn pigs occurred within 4 days of birth. Increased litter size resulted in decreased birth weights, an increased percentage of stillborn piglets and mummified fetuses. 70% of deaths by overlying were in previously healthy piglets, 18% were associated with illness in the sow. Savaging was mainly in first parity sows and was responsible for 20% of all deaths in these litters. 62% of all piglets with a birth weight of less than 800 gm were stillborn or died compared with 18.7% mortality for all piglets. Anaemia was considered due to umbilical haemorrhage and anaemic piglets had a 36% mortality to weaning whereas normal piglets had 10%. Splayleg occurred in 5.5% of piglets born alive and was related to use of Landrace boars. 24% of splayleg cases died.

Sub-Category: Mortalities of Young Stock
 Disease: Perinatal, Neonatal and Pre-Weaning Mortalities
 Species Affected: Pigs
 Region: Eastern Asia
 Country: China

Reference: Yang *et al.* (1987)

Population Studied: 8235 sows

Type Of Study: Survey

Abstract: A survey of 19 pig farms in Hubei Province found 3390 cases of Breeding Disturbance Syndrome in 8235 sows. Abortions were recorded in 162 sows, infertility in 501, stillbirths in 1723 and weak piglets in 542. 443 sows produced litters of less than 5 piglets each. 10849 piglets were lost out of 84392 born.

Sub-Category: Female Reproductive Disorders
 Disease: General Infertility
 Species Affected: Buffaloes
 Region: Southern Asia
 Country: India

Reference: Hodge and Rai (1972)

Population Studied: Unspecified Murrah buffalo population on a coastal farm in Mysore

Type of Study: Retrospective study of farm records

Abstract: The percentages of calves born in January-March, April-June, July-September and October-December was 9.13, 17.68, 41.88 and 64.57% respectively. Average age at first calving was 1970 days, average calving interval was 489 days.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Dani and Gaikwad (1972)

Population Studied: 155 Murrah buffalo on three farms in Akols

Type of Study: Retrospective study of farm records

Abstract: 90 % of all calvings took place between June and December. The peak number of calvings took place in August (rainy season) (22.3, 30.11, and 16.43 % of all calvings on the three farms respectively). The lowest number of calvings took place in April (1.79, 0.77 and 1.35 %). Buffaloes calving in August had the shortest average calving interval (412 days) and those calving in January and February the longest (535 and 542 days).

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Anderson (1985)

Population Studied: 36 dairy farms containing 7050 dairy cows and 1460 yearlings

Type of Study: Survey

Abstract: A two year study of 36 dairy farms revealed a culling rate for infertility of 6.3 %.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Eastern Europe
Country: Poland

Reference: Zwolinska-Bartczak *et al.* (1978)

Population Studied: Cattle on eight farms

Type of Study: Outbreak Investigation

Abstract: Data were obtained on 2865 cows at 12 farms within a 13 km radius of a smelter. The content of lead in the blood of cows averaged 0.245 mg/ml for those on the farm nearest to the smelter to 0.046 mg/ml for those from the most distant farm. Calving intervals of 392-416 days were recorded for cows from 3 farms with highest lead levels as against 375 days for cows with the lowest lead levels.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Latin America
Country: Brazil

Reference: Oliveira Filho *et al.* (1975)

Population Studied: A herd of 633 Nellore cows

Type of Study: Retrospective study of farm records

Abstract: Data on 2738 calvings of 633 Nellore cows were analyzed. The highest percentage of calvings (13.09 %) occurred in July and the lowest (0.98 %) in January. 63.23 % of all calvings occurred during the dry season. The average calving interval was 424 days and the average service period was 133 days. Season had a marked effect on both calving interval and service period with the shortest calving interval (417 days) and service period (126 days) occurring during the dry season as opposed to 434 and 143 days in the wet season.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Bodisco *et al.* (1976)

Population Studied: Brown Swiss crossbred cows in six herds

Type of Study: Retrospective study of farm records

Abstract: Data on 2238 calving intervals and 2278 service periods of Brown Swiss crossbreds in six herds were analyzed. Calving interval averaged 449.3 days and service interval 154.1 days. Both were significantly affected by parity, herd, year and month of calving and herd x month and year x month interactions.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Latin America
Country: Venezuela

Reference: Garcia Betancourt *et al.* (1973)

Population Studied: Brown Swiss crossbred cows on three farms in Araure district

Type of Study: Retrospective study of farm records

Abstract: 1948 milk and 1467 reproductive records of Brown Swiss crossbred cows on three farms were analyzed. Calving interval and service period averaged 400.5 and 120.2 days respectively. Both were affected by season with cows calving in September and November showing the best and those calving between December and May the poorest performance.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Panda (1972)

Population Studied: 1635 local Bengali and 547 Haryana X Bengal cows in West Bengal

Type of Study: Retrospective study of farm records

Abstract: Data was analyzed on the above cows. The incidence of cows showing oestrous during summer (March-June), winter (November-February) and monsoon (July-October) was 40.8, 34.7 and 24.5% respectively. For local cows the calving rate ranged between 38.7% (September) and 59.1% (April). For crossbreds the calving rate ranged between 36.4% (November) and 64.9% (April).

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Sheep
Region: Latin America
Country: Chile

Reference: Clara (1977)

Population Studied: 1581 Corriedale ewes on the Magallanes

Type Of Study: Retrospective study of farm records

Abstract: Data on 947 adult and 634 two-tooth Corriedale ewes grazed on either tussock or scrub pasture were analyzed. 23.35% of ewes grazing on tussock and 18.33% grazing on scrub were infertile.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Pigs
Region: Eastern Asia
Country: Korea

Reference: Chung *et al.* (1984)
Population Studied: 1153 slaughter sows
Type of Study: Survey
Abstract: 38.6% of 1153 slaughter sows were culled because of reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Pigs
Region: Eastern Asia
Country: China

Reference: Yang *et al.* (1987)
Population Studied: 8235 sows
Type Of Study: Survey; methodology unspecified
Abstract: A survey of 19 pig farms in Hubei Province found 3390 cases of Breeding Disturbance Syndrome in 8235 sows. Abortions were recorded in 162 sows, infertility in 501, stillbirths in 1723 and weak piglets in 542. 443 sows produced litters of less than 5 piglets each. 10849 piglets were lost out of 84392 born.

Sub-Category: Female Reproductive Disorders
Disease: General Infertility
Species Affected: Pigs
Region: Eastern Europe
Country: Yugoslavia

Reference: Salehar and Kovac (1986)
Population Studied: 9400 sows
Type of Study: Retrospective study of production records
Abstract: During 1982-84 data were obtained on 9400 sows from 4 farms in Slovenia. The average sow farrowed 4.98 times and produced 48.32 live piglets. The culling rate on the four farms ranged from 17.9% to 22.4%. 44.4% of sows were retained until the fifth litter. 13% were retained until the tenth litter. Reproductive disorders accounted for 42.07% of culls, selection for 25.68% and other health problems for 20.46%.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Buffalo
Region: Western Asia
Country: Pakistan

Reference: Samad *et al.* (1987)
Population Studied: 17293 buffaloes with reproductive disorders
Type of Study: Retrospective study of farm records
Abstract: Obstetrical problems - vaginal and uterine prolapse, placental retention, dystocia and abortion accounted for 13.5% out of a total of 17293 reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Cattle
Region: Eastern Europe
Country: Rumania

Reference: Medrea *et al.* (1984)

Population Studied: 188 bovine foetuses

Type of Study: Retrospective study of laboratory records

Abstract: Pregnancy toxemia was identified as the cause of abortion in 31.4% of 188 aborted foetuses submitted for laboratory diagnosis.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: George (1976)

Population Studied: Unspecified number of Dorset Horn Ewes

Type of Study: Longitudinal monitoring

Abstract: The frequency of dystocia was recorded in flocks of Dorset Horn ewes lambing in winter, spring and summer at stocking rates of 8, 12 or 16 ewes per hectare. More ewes experienced difficulties in lambing in winter (35%) and spring (39%) than summer (26%). 36% of perinatal mortality was ascribed to dystocia. Dystocia was more frequent in two year old ewes and foetal size was an important pre-determining factor.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Sheep
Region: Eastern Europe
Country: Yugoslavia

Reference: Petkov *et al.* (1979)

Population Studied: Unspecified number of sheep flocks

Type of Study: Outbreak Investigation

Abstract: Abortion rates in sheep flocks grazing in the vicinity of a lead smelter during 1975 ranged from 10-40%. Lead and cadmium contents of liver (2.31 mg%) and kidney (1.44 mg%) were much higher than in control animals from another district (0.52 and 0.129 mg% respectively). The sheep were generally in poor condition and lambs born alive were underdeveloped and of low viability.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Sheep and Goats
Region: Western Asia
Country: Iran

Reference: Hosseinion *et al.* (1972)

Population Studied: A mixed flock of 1500 sheep and goats near Teheran

Type of Study: Outbreak Investigation

Abstract: Five goats and 58 ewes died suddenly in a mixed flock grazing pasture heavily contaminated with *Astragalus* sp. All the flock were in poor condition. Some ewes aborted and others produced deformed lambs.

Sub-Category: Female Reproductive Disorders
Disease: Abortion
Species Affected: Pigs
Region: Eastern Asia
Country: China

Reference: Yang *et al.* (1987)

Population Studied: 8235 sows

Type Of Study: Survey

Abstract: A survey of 19 pig farms in Hubei Province found 3390 cases of Breeding Disturbance Syndrome in 8235 sows. Abortions were recorded in 162 sows, infertility in 501, stillbirths in 1723 and weak piglets in 542. 443 sows produced litters of less than 5 piglets each. 10849 piglets were lost out of 84392 born.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Buffalo
Region: Western Asia
Country: Pakistan

Reference: Samad *et al.* (1987)

Population Studied: 17293 buffaloes with reproductive disorders

Type of Study: Retrospective Study

Abstract: Obstetrical problems - vaginal and uterine prolapse, placental retention, dystocia and abortion accounted for 13.5% out of a total of 17293 reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Tanzania

Reference: Mtei (1983)

Population Studied: Cattle in traditional systems in four livestock development centres (LDCs) in Mwanza region

Type of Study: Longitudinal Monitoring

Abstract: The annual mortality rates in cows due to dystocia in the four livestock development areas were 0.0%, 0.0%, 0.1% and 1.9% respectively.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Pargaonkar and Bakshi (1987)

Population Studied: 546 cows

Type of Study: Survey

Abstract: 354 Red Khandari and 192 Jersey/Red Khandari cows were examined. The incidence of dystocia was 0.5% and 0.5% respectively.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Kleemann *et al.* (1986)

Population Studied: 286 Merino cross ewes and their offspring

Type of Study: Field experiment

Abstract: Ewes were fed different levels of dietary supplement. Lamb mortality was: singles 29%, twins 47%, triplets 66% and quadruplets 83%. The level of supplementation affected the mortality rates. Prolonged birth was the commonest identified cause of death (19.2 - 33.3%). Preparturient loss was 2.9% and peri-natal mortality was 5.4%.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Maxwell (1974)

Population Studied: Lambs in 68 sheep flocks in Western Australia

Type of Study: Survey

Abstract: Lamb mortality was studied in 68 flocks between 1967 and 1969. In 10 flocks that lambed in the spring of 1967, the lamb mortality rate ranged from 17.3 to 42.4%. Out of 1869 dead lambs studied, 14% of deaths occurred during difficult births.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Gumbrell and Saville (1986)

Population Studied: 21 commercial sheep farms

Type of Study: Survey

Abstract: The study examined over 23000 dead lambs on 21 commercial sheep farms over a five year period representing 9.8% of the total drop on these farms. Lamb losses on individual farms varied from 3% to 20%. 15% of dead lambs showed lesions of starvation and/or exposure. 27% showed lesions of dystocia and starvation/exposure suggesting that dystocia damaged lambs sufficiently to adversely effect their ability to feed and to seek shelter.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: George (1976)

Population Studied: Unspecified number of Dorset Horn Ewes

Type of Study: Longitudinal monitoring

Abstract: The frequency of dystocia was recorded in flocks of Dorset Horn ewes lambing in winter, spring and summer at stocking rates of 8, 12 or 16 ewes per hectare. More ewes experienced difficulties in lambing in winter (35%) and spring (39%) than summer (26%). 36% of perinatal mortality was ascribed to dystocia. Dystocia was more frequent in two year old ewes and foetal size was an important pre-determining factor.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Antipodes
Country: New Zealand

Reference: Gumbrell and Saville (1986)

Population Studied: 21 commercial sheep farms

Type of Study: Longitudinal Monitoring

Abstract: The study examined over 23000 dead lambs on 21 commercial sheep farms over a five year period representing 9.8% of the total drop on these farms. Lamb losses on individual farms varied from 3% to 20%. 47% of dead lambs showed lesions of dystocia without sign of other contributing causes. 27% showed lesions of dystocia and starvation/exposure suggesting that dystocia damaged lambs sufficiently to adversely affect their ability to feed and to seek shelter.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Latin America
Country: Brazil

Reference: Oliveira and Barros (1980)

Population Studied: 2774 Polworth ewes in a flock in Rio Grande do Sul

Type Of Study: Survey

Abstract: Of 200 lambs that died within 10 days of birth, 21% died as a consequence of dystocia.

Sub-Category: Female Reproductive Disorders
Disease: Dystocia
Species Affected: Sheep
Region: Latin America
Country: Peru

Reference: Ameghino *et al.* (1984)

Population Studied: Sheep population on a large ranch (estimated annual population of 177,000)

Type of Study: Longitudinal monitoring over a 10 year period

Abstract: Between 1971 and 1980 a total of 603694 lamb births were recorded. Mortality during the first three days of life was 36.94/1000 births and for the period from 4 to 30 days 5.87/1000. Weak lamb syndrome accounted for 17.5% of deaths.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Buffaloes
Region: Northern Africa
Country: Egypt

Reference: El-Wishy *et al.* (1988)

Population Studied: 1902 multiparous buffaloes

Type of Study: Survey

Abstract: Data on 1902 multiparous buffaloes were analyzed. 92.3% were non-pregnant. 20.9% of non-pregnant animals had macroscopic abnormalities of the genital tract, the commonest of which was non-cycling ovaries (14.1%).

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Buffaloes
Region: Southern Asia
Country: India

Reference: Hussain and Muniraju (1984)

Population Studied: 1155 female buffaloes

Type Of Study: Survey

Abstract: Examination of 1155 female buffaloes between January and June 1982 revealed anoestrus in 51% and various other reproductive disorders in 22%.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Buffaloes
Region: Western Asia
Country: Pakistan

Reference: Samad *et al.* (1987)

Population Studied: 17293 buffaloes with reproductive disorders

Type of Study: Retrospective Study

Abstract: Anoestrus accounted for 35.9% out of a total of 17293 reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Eastern Asia
Country: Korea

Reference: Kang *et al.* (1987)

Population Studied: 1200 native Korean and 240 Holstein cows

Type of Study: Survey

Abstract: The prevalence of ovarian cysts was 2.0% in 1200 Korean native cows and 7.9% in 240 Holstein dairy cows.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Hussain and Muniraju (1984)

Population Studied: 889 cows

Type Of Study: Survey

Abstract: Examination of 889 cows between January and June 1982 revealed anoestrus in 31% and various other reproductive disorders in 52%.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Chetty and Rao (1987)

Population Studied: 1463 cows and heifers

Type of Study: Survey

Abstract: In studies of 1463 healthy cattle (605 heifers, 858 cows) 49.2% were infertile (56.53% of heifers, 44.4% of cows). Anoestrus occurred in 191 (31.6%) heifers and 150 (17.5%) cows, repeat breeding in 62 (10.3%) heifers and 72 (8.4%) cows. Ovarian cysts were found in 6 (0.7%) cows. Retained corpora lutea in 9 (1.5%) heifers and 18 (2.1%) cows.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Rao *et al.* (1983)

Population Studied: 1975 crossbred cows

Type of Study: Retrospective study of clinical records

Abstract: Of 1975 crossbred cows examined between January and December 1981, 24.2% had anoestrus, 18.18% non-functional ovaries and 17.97% genital hypoplasia. The last two conditions were due to underfeeding.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Pargaonkar and Bakshi (1987)

Population Studied: 546 cows

Type of Study: Survey

Abstract: 354 Red Khandari and 192 Jersey/Red Khandari cows were examined. The incidence of anoestrus was 3% and 2% respectively and of repeat breeding 8% and 2%.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: South Eastern Asia
Country: Indonesia

Reference: Supriatna (1983)

Population Studied: 408 breeding females in six districts of Central Java

Type of Study: Survey

Abstract: 179 of 408 (43.9%) cows had infertility problems, 25% of which were related to anoestrus.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Cattle
Region: Western Asia
Country: Israel

Reference: Francos and Mayer (1988)

Population Studied: 120 dairy herds

Type of Study: Retrospective study of farm records

Abstract: Data on reproductive disorders were summarised for a two year period from 120 kibbutz herds (88000 calvings). The four most frequently diagnosed reproductive disorders were: retained placenta; lochia abnormal discharge diagnosed in the first 20 days post-partum; endometritis diagnosed after 20 days post-partum and anoestrus. 36 % of all cows calvings experienced one of these disorders. The average incidence for these disorders was 8, 6, 3.4 and 18% respectively. The conception rate after these disorders was 36.4, 34, 29.3 and 34.3 % respectively. The mean periods to conception were 116, 112, 118 and 129 days respectively. Cows with these disorders were 3.5-4 times more likely to be culled than healthy cows. The percentage of cows culled in the five month period after a uterine disorder was 12%.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Goats
Region: Southern Asia
Country: India

Reference: Ramachandran *et al.* (1984a)

Population Studied: 950 female slaughter goats at Cochin Abattoir

Type of Study: Abattoir study

Abstract: The genitalia of 950 female slaughtered goats was examined. Ovarian abnormalities occurred in 3.4 % of cases. These cases were comprised of hypoplasia 0.3 %, cystic degeneration 0.9 %, cystic corpus luteum 0.4 %, chronic oophoritis 0.2 %, multifollicular atresia 0.1 %, parovarian cyst 1.4 %.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Sheep
Region: Western Asia
Country: Pakistan

Reference: Ahmed *et al.* (1986)

Population Studied: 2357 female slaughter sheep at Faisalabad Abattoir

Type of Study: Abattoir study

Abstract: The ovaries of 2357 female slaughtered sheep were examined. 2.29 % of the sheep had diseased ovaries. These included follicular cysts (0.15 %), luteal cysts (0.09 %), cystic corpora lutea (1.46 %), persistent corpora lutea (0.21 %), ovario-bursal adhesions (0.30 %) and oophoritis (0.08 %).

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Sheep
Region: Western Asia
Country: Turkey

Reference: Türkarslan, M.T. (1986)

Population Studied: 1210 slaughter ewes

Type of study: Abattoir investigation

Abstract: Between November 1979 and August 1980 the genital organs of 1210 ewes were examined. Abnormalities were found in the ovaries of 112 (9 %) and in the oviducts of 177 (15 %).

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Horse
Region: Latin America
Country: Mexico

Reference: Saltiel *et al.* (1986)

Population Studied: 325 slaughter mares

Type of Study: Abattoir survey

Abstract: Oviducts from 325 mares (271 of which were pregnant) collected from an abattoir near Mexico city were evaluated macroscopically. Oviducts from 124 of these mares were evaluated microscopically; 285 (87%) of the mares had at least one macroscopic lesion. 49 of the 54 pairs of oviducts collected from pregnant mares had at least one macroscopic or microscopic lesion.

Sub-Category: Female Reproductive Disorders
Disease: Ovarian Disorders
Species Affected: Pigs
Region: Eastern Europe
Country: Yugoslavia

Reference: Zivkovic *et al.* (1986)

Population Studied: 8736 culled sows

Type of Study: Survey

Abstract: During 1983-84 data were obtained on 8736 culled sows from 8 farms producing 15000 - 50000 growing/finishing pigs per year. The average breeding life of the culled sows was 4.8 litters (range 3.2 to 7.3). There was a very high correlation between age at first farrowing and breeding life. The main reasons for culling were: return to oestrous (20.5%); anoestrus (15.9%), small litters (15.7%), agalactia (12.1%) and locomotor disorders (9.1%). It was concluded that early culling was mainly due to poor breeding management, such as inseminating too early and failure to detect oestrous.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Buffalo
Region: Western Asia
Country: Pakistan

Reference: Samad *et al.* (1987)

Population Studied: 17293 buffaloes with reproductive disorders

Type of Study: Retrospective Study

Abstract: Obstetrical problems - vaginal and uterine prolapse, placental retention, dystocia and abortion accounted for 13.5% out of a total of 17293 reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Buffalo
Region: Southern Asia
Country: India

Reference: Dutta and Dugwagar (1983)

Population Studied: 192 calving buffaloes in the Panjab

Type of Study: Production Records

Abstract: Of 192 buffaloes calving between June 1979 and May 1980, retained placenta occurred in 4.69%.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Buffalo
Region: Southern Asia
Country: India

Reference: Tomar and Tripathi (1986)

Population Studied: Two Institutional Herds of Buffalo

Type of Study: Retrospective Study of Production Records

Abstract: A study was made of the incidence of retained placenta in 384 buffalo from the National Dairy Research Institute (NDRI) herd and 541 from the Military Dairy Farm (MDF) herd. Data covered a period of 11 and 24 years for the two herds respectively. During first lactation, the average incidence of retained placenta for the NDRI and MDF herds respectively was 7.30 and 3.63 %.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Cattle
Region: Western Asia
Country: Israel

Reference: Francos and Mayer (1988)

Population Studied: 120 dairy herds

Type of Study: Retrospective study of farm records

Abstract: Data on reproductive disorders were summarised for a two year period from 120 kibbutz herds (88000 calvings). The four most frequently diagnosed reproductive disorders were: retained placenta; lochia abnormal discharge diagnosed in the first 20 days post-partum; endometritis diagnosed after 20 days post-partum and anoestrus. 36 % of all cows calvings experienced one of these disorders. The average incidence for these disorders was 8, 6, 3.4 and 18 % respectively. The conception rate after these disorders was 36.4, 34, 29.3 and 34.3 % respectively. The mean periods to conception were 116, 112, 118 and 129 days respectively. Cows with these disorders were 3.5-4 times more likely to be culled than healthy cows. The percentage of cows culled in the five month period after a uterine disorder was 12 %.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Dutta and Dugwagar (1983)

Population Studied: 130 calving cattle in the Punjab

Type of Study: Production Records

Abstract: Of 130 cattle calving between June 1979 and May 1980, retained placenta occurred in 18.46 %.

Sub-Category: Female Reproductive Disorders
Disease: Retained Placenta
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Pargaonkar and Bakshi (1987)

Population Studied: 546 cows

Type of Study: Survey

Abstract: 354 Red Khandari and 192 Jersey/Red Khandari cows were examined. The incidence of retained placenta was 3 % and 2.5 % respectively.

Sub-Category: Female Reproductive Disorders
Disease: Utero-Vaginal Prolapse
Species Affected: Buffalo
Region: Southern Asia
Country: India

Reference: Tomar and Tripathi (1986)

Population Studied: Two Institutional Herds of Buffalo

Type of Study: Retrospective Study of Production Records

Abstract: A study was made of the incidence of utero-vaginal prolapse in 384 buffalo from the National Dairy Research Institute (NDRI) herd and 541 from the Military Dairy Farm (MDF) herd. Data covered a period of 11 and 24 years for the two herds respectively. During first lactation, the average incidence of utero-vaginal prolapse for the NDRI and MDF herds respectively was 7.74% and 1.16%.

Sub-Category: Female Reproductive Disorders
Disease: Utero-Vaginal Prolapse
Species Affected: Buffalo
Region: Western Asia
Country: Pakistan

Reference: Samad *et al.* (1987)

Population Studied: 17293 buffaloes with reproductive disorders

Type of Study: Retrospective Study

Abstract: Obstetrical problems - vaginal and uterine prolapse, placental retention, dystocia and abortion accounted for 13.5% out of a total of 17293 reproductive disorders.

Sub-Category: Female Reproductive Disorders
Disease: Utero-Vaginal Prolapse
Species Affected: Cattle
Region: Southern Asia
Country: India

Reference: Pargaonkar and Bakshi (1987)

Population Studied: 546 cows

Type of Study: Survey

Abstract: 354 Red Khandari and 192 Jersey/Red Khandari cows were examined. The incidence of cervico-vaginal prolapse was 0.5% and 0.5% respectively.

Sub-Category: Female Reproductive Disorders
Disease: Unspecified Uterine Abnormalities
Species Affected: Sheep
Region: Western Asia
Country: Turkey

Reference: Türkarslan, M.T. (1986)

Population Studied: 1210 slaughter ewes

Type of Study: Abattoir investigation

Abstract: Between November 1979 and August 1980 the genital organs of 1210 ewes were examined. Abnormalities were found in the uteri of 158 (13%).

Sub-Category: Male Reproductive Disorders
Disease: Cryptorchidism
Species Affected: Goats
Region: Southern Asia
Country: India

Reference: Janardhana Pillai *et al.* (1985)
Population Studied: 3594 slaughter rams in Andhra Pradesh
Type of Study: Abattoir investigation
Abstract: Cryptorchidism was found in 1.14% of the 3594 rams examined.

Sub-Category: Male Reproductive Disorders
Disease: Cryptorchidism
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Trejo *et al.* (1988)
Population Studied: 327 slaughter rams
Type of Study: Abattoir investigation
Abstract: 3% of 327 rams sent for slaughter were affected by cryptorchidism.

Sub-Category: Male Reproductive Disorders
Disease: Cryptorchidism
Species Affected: Sheep
Region: Southern Asia
Country: India

Reference: Janardhana Pillai *et al.* (1985)
Population Studied: 5210 slaughter rams in Andhra Pradesh
Type of Study: Abattoir investigation
Abstract: Cryptorchidism was found in 1.11% of the 5210 rams examined.

Sub-Category: Male Reproductive Disorders
Disease: Scrotal Abnormality
Species Affected: Sheep
Region: Antipodes
Country: Australia

Reference: Burgess (1983)
Population Studied: 553 slaughter rams over one year in Victoria
Type of study: Abattoir investigation
Abstract: 553 mature rams were examined. 22% showed scrotal adhesions, 7% epididymitis (Merino 3.6% British breeds 13.5%).

Sub-Category: Male Reproductive Disorders
Disease: Testicular Hypoplasia
Species Affected: Sheep
Region: Latin America
Country: Mexico

Reference: Trejo *et al.* (1988)
Population Studied: 327 slaughter rams
Type of Study: Abattoir investigation
Abstract: 1.2% of 327 rams sent for slaughter were affected by testicular hypoplasia.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: McLennan (1988)

Population Studied: Cattle in 83 dairy herds

Type of Study: Survey

Abstract: Causes of lameness in 185 treated cases in 83 dairy herds attended by nine practices. Average incidence of lameness requiring treatment by the veterinarian was 2.7 cases per 100 cows per nine months with a range between practices of 1.4 to 5.5%. Foot lesions accounted for 83.2% of all lesions with limb lesions accounting for the other 16.8%. 50% of the latter occurred in the hip and stifle. Trauma was the major cause of limb lesions. The most common foot lesions were interdigital necrobacillosis (15%), deep sepsis (8.9%), white line disease (8.4%), axial groove fissure (8.4%) and foreign body in the sole/heel (5.6%).

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Antipodes
Country: Australia

Reference: Harris *et al.* (1988)

Population Studied: Cattle in 73 dairy herds

Type of Study: Survey

Abstract: 73 dairy herds were surveyed during the calving season (March to November) 1985. Lameness occurred in 64 herds. Mean incidence was 7.0% with a range of 0 to 30.9%. The mean cost was estimated at \$42.90 per cow due to loss of production, treatment, culling or death and extra man hours spent managing lame cows. It was concluded that site, construction, maintenance and use of farm track were of major importance as predisposing factors.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Antipodes
Country: New Zealand

Reference: Anderson (1985)

Population Studied: 36 dairy farms containing 7050 dairy cows and 1460 yearlings

Type of Study: Survey

Abstract: A two year study of 36 dairy farms revealed that 3.6% of the animals received treatment for lameness.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Eastern Asia
Country: Korea

Reference: Kim (1985)

Population Studied: 310 holsteins and 231 native cattle

Type of Study: Abattoir study

Abstract: Examination of the above number of cattle in an abattoir in July - August 1984, revealed foot diseases in 13% of holstein and 9% of Korean native cattle. Chronic necrotic pododermatitis was seen in 35 of the 61 affected animals. Other conditions were foot rot (12 cases), interdigital fibroma (6), papilloma (2), laminitis (3) and puncture wounds (3).

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Southern Asia
Country: Sri Lanka

Reference: Bauman (1983)

Population studied: Cattle on three large scale dairy development farms 1978-1981

Type of study: Retrospective study of farm records

Abstract: Over the three year period the annual loss in adult cattle due to culling or mortality ranged between 2-15% per year. Lameness accounted for 38% of total mortalities/culls.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Western Asia
Country: Israel

Reference: Bargai and Cohen (1988)

Population Studied: 20 bulls at two A.I. centres

Type of Study: Clinical examinations

Abstract: 20 bulls which showed signs of pain or external damage of the tarsus were examined at two A.I. centres. 16 showed signs of degenerative joint disease. A retrospective survey of radiological examinations of the tarsi in the last 25 years indicated that bulls are much more affected than cows. The disease was more commonly seen in dairy as compared to beef bulls. The disease is thought to be associated with the practice of using young immature bulls as teasers.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Cattle
Region: Sub-Saharan Africa
Country: Tanzania

Reference: Mgassa *et al.* (1984)

Population Studied: 225 slaughter cattle

Type of Study: Abattoir study

Abstract: Examination of the above number of adult cattle in an abattoir revealed subclinical or chronic pododermatitis in 54.7% of the animals.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Horses
Region: South Eastern Asia
Country: Malaysia and Singapore

Reference: Lim Ah Soo (1986)

Population Studied: 1161 racehorses

Type of Study: Clinical records

Abstract: In 1986 31.6% of the racehorse population had joint, tendon, ligament or foot conditions predisposing them to lameness.

Sub-Category: Lameness
Disease: Lameness
Species Affected: Horses, Donkeys, Mules
Region: Northern Africa
Country: Egypt

Reference: Bolbol and Saleh (1987)

Population Studied: 2347 horses, donkeys and mules

Type of Study: Survey

Abstract: Lameness accounted for 46.5% of 2347 surgical affections in horses, donkeys and mules. Forelimbs were affected in 69.6% of 1092 cases, hind limbs in 28.7% and both limbs in 1.7%. The commonest conditions seen were septic pododermatitis (44.1%), corns (29.2%), coronitis (8.9%), seedy toe (7.4%), hoof cracks (5.5%), thrush (2.6%), laminitis (1.4%) and quittor (0.9%).

Sub-Category: Lameness
Disease: Lameness
Species Affected: Pigs
Region: Eastern Asia
Country: Korea

Reference: Chung *et al.* (1984)

Population Studied: 1153 slaughter sows

Type of Study: Survey

Abstract: 23.3% of 1153 slaughter sows were culled because of lameness and arthritis.

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FOOD LOSSES DUE TO MINERAL DEFICIENCIES AND PROGRAMME FOR THEIR REDUCTION

by

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SUMMARY

In any region of the world, a major problem associated with the development of livestock industries is the supply of feed of good quality.

Nutrient deficiencies may arise as a result of bad management or lack of a specific nutrient or imbalance in a particular area. Especially, mineral deficiencies are often confined to specific geographical location. In many soils there are deficiencies or imbalances that are reflected in the composition of pastures producing clinical or subclinical deficiencies in animals grazing on these areas. These mineral deficiencies or imbalances have long been held responsible for low production among grazing cattle in extensive systems, showing important productivity losses in Latin American countries.

Limited information is available regarding quantitative data on financial losses due to mineral deficiencies. There are mainly technical data with references to physical losses in productive terms like pregnancy rate, abortion and calving percentage, death losses from birth to weaning, growth rate, weaning weight, etc. Only a few examples of calculated cost/benefit ratio of feeding minerals in grazing rangelands were found in the literature.

This paper deals with a brief description of the main mineral deficiencies reported in Latin American countries with more emphasis in ruminants. Also, comments on diagnostic methods are given, and a few examples of reported productive losses due to mineral deficiencies are presented.

Due to the limited economic data available, a tentative proposal to evaluate the productive and financial losses of mineral deficiencies and a programme for their reduction is suggested.

Finally, several recommendations are listed that may contribute to the action to be taken to improve the diagnosis, prevention and control of mineral deficiencies, and to reduce productivity and food losses.

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INTRODUCTION

Mineral elements have been recognized for many years as essential dietary nutrients for animals. One group of these elements, generally referred to as "macro" elements, includes Ca, P, K, Na, Cl, Mg and S. Another group of elements are referred to as "micro" or "trace" elements. At the present time, 14 trace elements are believed to be essential for animal life: Fe, I, Zn, Cu, Mn, Co, Mo, Se, Cr, Tin, Vanadium, Silica, Nickel and Arsenic.

The extensive global distribution of mineral element problems can be estimated from reports such as those of FAO/OIE/WHO Animal Health Yearbook. For example, considering data from 1980, with more than three-quarters of the world's countries providing information, 80% reported nutritional disorders of moderate or high incidence. Mineral deficiencies or toxicities were involved in more than half of those whose causes were identified.

PREVALENCE OF MINERAL DEFICIENCIES IN LATIN AMERICA

Mineral deficiencies for herbivores are reported from many developing countries of the world. Several investigators have made important contributions reviewing the confirmed and/or highly suspected geographical areas of mineral deficiencies and imbalances in Latin America (24), (16), (27), (29).

Miles & McDowell (34) indicated that the 300 million hectares of savannah rangelands and the 550 million hectares of forest of the low humid tropics of South America constitute an area with possibly the greatest potential for expansion of beef production anywhere in the world, pointing out that Latin America as a whole has approximately twice the cattle numbers of the USA but only half the beef production (45), (51).

In explaining the low productivity, many diseases and tropical climate are important factors but a low level of nutrition is considered to be the major problem. The lack of sufficient energy and protein is often responsible for suboptimal livestock production. However, numerous investigators have observed that cattle sometimes deteriorate in spite of an abundant feed supply (27). Nevertheless, in many areas of Latin America mineral deficiencies, imbalances and toxicities severely inhibit the grazing livestock industry, being responsible for low production and reproductive problems. Grazing livestock do not often receive mineral supplementation and must depend largely upon forages to supply their mineral requirements. Borderline or deficient levels of certain elements were noted in many forages in Latin America (28). This limitation may produce in the animals clinical signs such as loss of appetite, pica, diarrhoea, wasting, depigmented hair, skin disorders, slow growth rate, low fertility, abortion and bone abnormalities.

As pointed out by E.J. Underwood, phosphorus deficiency is the most widespread and economically important of all the mineral deficiencies affecting grazing livestock (59). It has been reported in 38 developing tropical countries, followed by Copper deficiency in 21, Cobalt deficiency in 20, Magnesium deficiency in 17, Iodine deficiency

in 15 and Sodium deficiency in 14 (16). Generally, deficiencies of Copper and Cobalt are more detrimental to cattle production than either Sodium and Iodine. Selenium deficiency appears lately worldwide distributed and producing remarkable losses. Magnesium imbalance is confined to specific areas with seasonal variations.

In Argentina, investigators from the National Institute of Agriculture Technology (INTA) and other institutions have made important contributions to characterise and evaluate the mineral deficiencies in farm animals (1). A project supported by FAO/SF/ARG 8 (42) contributed to discovering the cause of "Enteque Seco", a Ca:P imbalance condition produced by the ingestion of a plant *Solanum malacoxylon*, which contains a vitamin D-like metabolite, producing a general mineralization of soft tissues and bone abnormalities due to vitamin D toxicity, affecting grazing livestock with considerable economical losses (53) (7).

Bingley and Carrillo working in this FAO project defined the hypocuprosis in cattle (42) demonstrating that causal relationship can be drawn between the hypocuprosis of cattle and the Copper, Molybdenum and Sulphate contents of the forage which they graze (4) (5). These investigators with Ruksan, B.E., also reported serious productive losses and the favourable response to Copper supplementation, either orally or given as Cu-EDTA subcutaneously, in preventing these conditions (6), (8), (9).

Phosphorus deficiency was reported in Argentina by Kraemer and Mufarrege, indicating the low content of P in pasture and blood, bone abnormalities (osteomalacia) and low fertility (20).

In a more recent report Mufarrege *et al.* demonstrated the beneficial effect of supplementation of P (bone meal and salt) to increase the fertility rate and the beef production per hectare (35). The low content of P and Na in native pasture seems to be the more important cause of low production in cattle and sheep. They prevent the deficiency by giving a mineral mixture containing 6% P, 12% Ca and 50% salt (1).

Hypomagnesemia with tetany was reported in Argentina especially during the winter months in breeding cows grazing cereals (oats, barley, rye) or native lush pasture. Also, hypomagnesemia in sheep (44) and in dairy cattle has been reported. The supplementation of dry forages and MgO with management practices contributed to avoid this condition (43) (47).

In a recent review, Ruksan summarized the incidence of microelement deficiencies in Argentina, mapping the concentration value of Copper, Selenium, Zinc, Manganate, Cobalt, Molybdenum and Iron obtained in pasture analysis of different areas of the country (46). Conditioned Copper deficiency resulted in the most important microelement condition, widespread in various areas and producing considerable physical losses like unthriftiness, slow growth rate, depigmentation, diarrhoea, lower weaning weights, reproductive failure and bone abnormalities (46). As mentioned, the deficiency is of a "conditioned type" with excess of Molybdenum in pastures and excess of Sulphate in pastures and water (4), (6), (8). It affects mainly bovines but was also reported in sheep (2). The Copper values in pastures ranged between 5 - 10 ppm. The Molybdenum concentration is over 2 ppm with values up to 40 - 50 ppm and the Sulphate contents are over 0,5 percent dry weight (6), (8), (46).

Selenium studies in cattle and sheep were done using the blood glutathion peroxidase concentration as indicator of the Se status. Low values were found in various areas of Argentina (46) and clinical cases of "white muscle disease" were observed in Santa Fe Province in a lot of 450 calves with a morbidity of 22.2% and a mortality of 8.9% (14). A good response to fertility was observed in heifers with the combined administration of Selenium and Copper (49).

Iodine deficiency in man and farm animals as endemic goitre was reported in various areas, but especially in the north of Argentina. Deficiency of Iodine results in a lack of T_3 and T_4 and is manifested by general weakness, stunted growth or stillborn animals with goitre.

In breeding animals Iodine deficiency affects the oestrus cycle in the female and produces lack of libido in the male (27), it is reported in northern Argentina producing goitre in cattle and man (1), (22). The incidence of deficiency has declined as a result of the use of iodized salt but cases still remain in confined areas.

Zinc and Cobalt are also reported as limited in pasture analysis with favourable response to supplementation. Manganese is borderline and Iron appears in excess with possible interrelation with Copper deficiency (46).

In Bolivia, in a three years experiment designed to determine the mineral status of grazing beef cattle in the Beni Region, it was reported that deficient concentration were found in pasture analysis for Phosphorus, Sodium, Copper and Zinc. Calcium and Selenium levels were low during some collection periods (25), (39). Animals receiving the supplement containing P and Ca (salt + bone meal) had higher bodyweight gains ($P < 0.01$) than controls (30).

In Brazil, Tokarnia C., Dobereiner J. and Moraes S. published in 1988 a review of the studies made on disorders of mineral metabolism in cattle, mainly mineral deficiencies and on botulism as an important complication of Phosphorus deficiency (58). They reported deficiencies of Phosphorus, Sodium, Copper, Cobalt, Iodine, Zinc and Manganese, the last depending on the excess of Fe in the pasture. Low values of Selenium in liver and blood serum were observed. They reported hypocalcemia due to ingestion of pasture rich in Oxalates and also toxicity of Copper and Fluorine. The paper is illustrated with maps of Brazil indicating the deficient element in various areas.

In Colombia, range forages on the eastern plains or "llanos" rangelands have marked deficiencies of minerals affecting the proper nutrition of cattle and producing food losses. Based on recently available forage analysis data from three widely separated areas it was concluded that Phosphorus, Calcium, Sodium, Copper, Zinc, Cobalt, Sulphur and Selenium are usually below recommended levels for cattle (34). Magnesium and Potassium tend to range from the borderline to adequacy. Iron and Manganese are high to excessive. The forage analysis data were on samples collected by the Instituto Colombiano Agropecuario (ICA) (21).

In a more recent report, Vargas R. *et al.*, 1984, reconfirmed those deficiencies and indicated that deficiencies specifically related to "secadera" disease would likely be Zinc and Copper deficiencies, aggravated in some instances by excess of Molybdenum (61).

In Chile, deficiencies of Phosphorus, Magnesium and Iodine were described (12), (18), (40).

In Ecuador, Phosphorus deficiency is predominant (15), (24) but Sulphur, Iodine and Selenium deficiencies have been also described.

Paraguay reported Phosphorus, Iodine and Selenium deficiencies. In Peru, deficiencies of Phosphorus, Calcium, Magnesium, Cobalt, Copper, Selenium and Zinc have been described (16), (24), (60).

In Venezuela, Phosphorus, Calcium, Sodium, Zinc and Potassium deficiencies have been reported (10), (16), (17), (24), (62).

From Uruguay, deficiencies of Phosphorus, Copper, Cobalt, Iodine, Selenium and Magnesium were reported (16), (24), (37), (38).

The available information about mineral deficiencies in South America is summarized in a map as presented in Figure 1, page 121.

DIAGNOSIS OF MINERAL DEFICIENCIES OR IMBALANCES

Where the clinical signs of a specific mineral element deficiency are frankly present, it is a simple matter to confirm the diagnosis by analysis of animal fluids and tissues and verify if appropriate supplementation can overcome the problem. Difficulties arise when the performance of the stock is suboptimal (53) leading to mild and transient conditions expressed as a vague unthriftiness, unsatisfactory growth, suboptimal fertility, etc. (54). In these cases, the problem is particularly difficult to solve since mineral deficiency may overlap with a complex interplay of multiple nutritional deficit, infections and/or parasitic diseases.

One of the most reliable methods of confirming mineral deficiencies is the response derived from specific mineral supplementation. However, such studies are costly in time and resources if conducted with adequate control and assessment. The majority of mineral imbalances, particularly borderline conditions, do not result in pathological observations of clinical signs specific to a single mineral. Therefore, in order to determine mineral insufficiencies chemical analysis and biological assays are often required (26).

Several approaches can be used to characterize mineral deficiencies or imbalances:

1. Analysis of soil

The mineral status of livestock is largely dependent upon the mineral content of pastures and this is influenced by nutrients available in the soil (26). Thus, in some instances, a soil survey can provide clues to potential livestock deficiencies, besides that several factors can affect forage mineral uptake from soils limiting the precision of the information (26). However, in order to cover huge areas at relatively low costs, soil analysis of mineral content may be fully acceptable in primary survey work, especially now with the introduction of low cost satellite-image techniques.

2. Forage analysis

Mineral analysis of forage consumed by the grazing animal is usually very useful to mineral status diagnosis. However, some problems limit the efficacy of this approach. First, the sample must be representative of what animals consume, which implies not only some knowledge of livestock grazing patterns but also estimations of dry matter intake. Second, there is a lot of variation in mineral availability from forages due to mineral interrelationships and blockage in gut absorption or metabolic utilization. Mineral deficiencies in grazing livestock can be predicted as a gross approximation by using a systematic mapping survey technique based on forage and animal tissue concentrations (15), (26).

3. Determination of mineral content of animal tissues and/or fluids

This is the most used technique to determine mineral status in animals. Ideally, it is desirable to measure the mineral content of one tissue that is readily available from a live animal, such as blood, urine, saliva, milk, faeces, hair, bone biopsies, etc. Unfortunately, no mineral concentration of any one tissue or fluid will portray the status of all minerals. Hence, the survey for several elements may be of high operative costs (16), (26).

4. Metabolic markers

Fundamental for the interpretation of data on mineral element content of animal tissues and fluids is the assumption that compositional anomalies will be reflected, ultimately, by changes in animal performance. Our current estimates of minimal mineral requirements are based, so far, upon balance trials or tissue compositional data rather than on physiological criteria. The development of "metabolic markers" for mineral status is now being seen as the best way to identify the consequences of suboptimal mineral intake before productivity declines (53). Ceruloplasmine and superoxide/dismutase for Copper deficiency (55), glutation peroxidase for Selenium deficiency, T_3 and T_4 for Iodine deficiency, methylmalonate for Cobalt deficiency (33) and probably plasma metalothioneine for Zinc deficiency are practical examples of this approach. In the future, it is believed that the determination of particular enzymes, transport proteins and metabolites with which the mineral in question is functionally associated, may be the most important indicators of mineral status. With the fast progress in biotechnology, monoclonal antibodies, antigen-antibodies (ELISA) and dry chemistry techniques, it would be of great interest, especially for developing countries with livestock production under range conditions, to develop cow-side fast semi-quantitative determinations (diagnostic kits) to detect mineral deficiencies. In that way and taking into account the difficulties and costs to install specialized laboratories, it will be easier to characterize the situation and to build up a data bank.

5. Productive and Economical Effect of Mineral Deficiencies

Mineral nutrition disorders range from acute mineral deficiency, characterized by well marked clinical signs and pathological changes to mild and transient conditions difficult to diagnose and expressed as a vague unthriftiness, slow growth and reproductive

failure. The latter assume great importance because they generally occur over large numbers of animals producing high productive and economical losses (31). Important is examination of the herd, management information, pasture production, clinical history and necropsy data, which will help to evaluate the problem leading to correct diagnosis and prevention. The observation of osteophagia with rickets or osteomalacia and low fertility would indicate P deficiency. The presence of endemic goitre, stillborn animals, suppression of oestrus periods in the female and lack of libido in the male with stunted growth would indicate I deficiency. Wasting and anaemia may result from Co deficiency. Diarrhoea with depigmentation of the hair, retarded growth would orientate to Cu deficiency, etc. (58). In other cases death due to a direct or indirect effect of the deficiency was reported. In Brazil, an estimated 2 - 3% of approximately 100,000 cattle die annually of botulism as a consequence of osteophagia due to P deficiency (56). Also in Argentina, Mufarrage *et al.*, in 1983, reported that due to P and Na deficiencies, cattle developed "pica" or "malacia" ingesting bones contaminated with *Cl. botulinum* and dying due to botulism (1), locally known as "Mal de Apaguey" (64). In addition, two disease conditions "cara hinchada" and "secadera" have been major determinants to cow-calf production in vast areas of Brazil and Colombia respectively. Although the etiology remains unidentified, both of these conditions have responded to adequate and balanced trace mineral supplementation (31). Another disease condition in the llanos of Venezuela is known as "borrachera", a type of falling disease. Animals with this condition have a very low tissue status of Copper but its etiology has yet to be established due to lack of controlled supplementation experiments (31).

Reports of improved weight gains, fertility and milk production by P supplementation to cattle have been summarized by McDowell, L.R. (32) from experiments performed in various Latin American countries. This investigator pointed out that the most devastating economic result of P deficiency is reproductive failure. Averaging 16 cattle reports on the effect of supplementation on calving percentage, those receiving P supplement have a 75.6% calf crop versus 52.9% for controls (32). Copper deficiency affected the reproductive function. Homse, A.C., working with cows experimentally treated with Mo to induce Cu deficiency, concluded that high Mo in the diet interferes with Cu absorption and in reproductive function to produce alteration in oestrus cycles and reproductive failure (19). Ruksan, B.E. *et al.* treated a group of heifer with Cu and kept another group as control in a study on the reproductive effect of Cu deficiency. They found 20% more cyclic ovarian activity and 15% higher pregnancy rate in the treated group vs. control (50).

Many reports from developing countries have revealed the beneficial effects of mineral supplementation on overall performance of productive animals (15), (57). Also, McDowell (1985) reported that a large number of experiments have shown dramatic production benefit from providing animal supplementation that result in high benefit/cost ratios (3). From Matto Grosso, Brazil, Sousa *et al.*, 1983, have shown that steers gained 40 kg. during 336 days when supplemented with only salt compared to 144 kg. when fed a complete mineral supplement. The cost/benefit ratio of this mineral supplementation was shown to be 1:26 (52).

Economic return on mineral investment has been at least two to one in Latin American studies (11). Using production data from the CIAT herd system in Colombia,

the mineral supplement cost and gross sales of beef, calculating the cost/benefit ratio of feeding minerals results in a dramatic return of 15.6 pesos per each peso invested in mineral mixtures compared to animals receiving only common salt. It is one demonstration that the economic return on mineral supplementation is high (29).

Experimental data from Argentina (41) show in areas with P (0.07%) and Na (0.03%) deficiencies that by providing animal supplementation (bone meal and salt), it is possible to improve the beef production per hectare from 40 - 50 kg. to 70 - 75 kg., an increase estimated to be about 60%. Thus, producing a plus return of 15 US\$/hectare and providing a cost of 3 - 4 US\$/hectare, resulting in a cost/benefit ratio of 1:3 to 1:4. Besides the implementation of both supplementation and fertilization on part of the land (that destined to the heifers) produced a higher increase in beef production of about 80 - 85 kg/hectare (nearly a 100% improvement), with a cost of 4 - 6 US\$/hectare resulting in a plus return per hectare of 23 US\$, with a cost/benefit ratio of 1:3 to 1:5 (36).

Regarding the reduction of production losses due to Cu and Se deficiencies from data available in Argentina, it was possible to demonstrate that the administration of these two microelements can reduce losses in beef and dairy cattle, increasing the pregnancy percentage, calving percentage and improvement of the live weight gains of calves, increasing the average beef and milk production per hectare with a considerable economic return.

STRATEGY AND POLICY TO EVALUATE AND TO DEAL WITH FOOD LOSSES DUE TO MINERAL DEFICIENCIES

1. Outline of proposed model to evaluate the economical impact of mineral deficiencies at the farm, regional and national levels

The estimation of economic losses due to mineral deficiencies should be based upon four kinds of survey and experimental works.

- 1.1 Define well characterized geographical areas and select target livestock production population (meat, milk, etc.).
- 1.2 Amount of the livestock population in the area under evaluation.
- 1.3 Throughout survey work based on pasture and/or animal clinical evaluation and/or tissues or fluid analysis, detect the mineral deficiency/ies which could limit animal productivity.
- 1.4 Representative farms in the area have to be tested to confirm the mineral deficiency. Livestock have to be divided into at least two groups, one of them receiving the mineral supplementation and the other remaining as non-treated control group (53). Physical losses (death rate, weaning weight, growth rate, final weight to slaughter, carcass composition and quality, reproductive efficiency, milk production, wool quantity and quality, etc.) should be evaluated by differences between groups and financial losses and cost/benefit ratio estimated from these results.

Then, by data extrapolation to the livestock population under mineral deficiency risk, regional data about economic losses to the primary sector (farm level) can be generated. Finally, losses of intermediary sector (retailer, exporters) and of the state/ country (fiscalization, taxes, trade, etc.) could be estimated (see attached scheme, Figure 2, page 122).

2. Suggested Programme for Reduction of Losses

- 2.1 Improve diagnosis. Development and use of "metabolic markers" and diagnostic kits to improve the characterization of subclinical conditions and the differential diagnoses with multiple deficiencies or imbalances and parasitic or infection disease.
- 2.2 Improve prevention and treatment. Methods of mineral supplementation can be classified according to the route of administration. For animals kept under intensive conditions, supplementation is usually given in the diet. In grazing animals on range conditions, additional minerals have to be given as mineral mixtures in feeders, blocks, licks, added to the water, fertilization or using slow-release pharmacological preparations for oral and/or parenteral administration.

The major problem with the use of free-access salt mixtures (licks or blocks) is to make sure that all animals take enough quantities of minerals to avoid the deficiency.

Several troubles are found in practice: lack of palatability of some mineral mixtures, need of good selection of sites to put the licks or blocks and possibility of the animals to have easy access to them, high levels of salt in water, which greatly reduce mineral mixture consumption. If minerals are added to drinking water, the existence of alternative water sources (streams, lakes, ponds) does not allow a reliable mineral intake.

Indirect methods of providing minerals to grazing cattle include use of mineral containing fertilizers, altering soil pH and encouraging growth of specific pasture species. Where economic and climatic considerations are favourable, fertilizer treatment of the soil is successful to improve both the yield and mineral composition of herbage (26), (36).

Slow-release parenteral or intra-ruminal preparations are excellent approaches for supplementation on range conditions, although limited to microelements because of the amount of material which can be added to these kinds of products. Their relative effectiveness is determined by the duration of protection and, in the case of rumen preparations, by their ability to prevent coating or regurgitation. In the last few years, besides the classical bullets for Co and Mg deficiency control, new products have been developed. Among them, the copper oxide needles (13), (48), barium selenite depot products and nonsilica glasses containing Cu and Se are the more conspicuous. However, there is a vast area for research looking for new slow-release products based on non-digestible cellulose, plastic polymers, new technology in subcutaneous implants with zero-order kinetic release which should be of great interest to test in livestock on grazing conditions.

- 2.3 Improve quality of mineral mixtures. Government and industry agreement to process and to evaluate the mineral mixtures to provide the biologically available form of each mineral element needed, in the right proportion, avoiding inclusion of toxic elements and formulated with sufficient palatability.
- 2.4 Developed field experimental trials to correct mineral deficiencies by a selected treatment in accord with the problem area and demonstrate to the farmers the feasibility to reduce the production losses under simple but well controlled conditions.
- 2.5 Extension and continuing education programme for private practitioners and farmers with emphasis on the diagnosis and evaluation of production losses due to mineral deficiencies and the economical benefit of its prevention and control.
- 2.6 Any proposal should be coordinated with the Rural Sociology Department in order to complement the program with an educational campaign giving a full participation to the rural family.

RECOMMENDATIONS

1. FAO should coordinate the identification at the regional level with countries, their own capacities in technical resources and facilities, for diagnosis, productive evaluation, prevention and control of mineral deficiencies.
2. In selected regions or countries where enough technical information is available, FAO may consider the development of TCP projects to demonstrate the economical impact of prevention and control of mineral deficiencies to increase productivity and reduce losses.
3. With the information obtained and evaluated in item 1, FAO should consider the organization of TECHNICAL COOPERATION NETWORKS to study the nutritional deficiencies of major importance for individual countries of the regions, accounting for the economical effects of their correction.
4. Workshops and training courses should be held whenever possible for selected subjects.
5. Develop and standardize simple reliable diagnostic methods for the main mineral element deficiencies to use in diagnostic and research laboratories of developing countries to characterize deficiencies and to differentiate from other conditions. FAO should assist to prepare and distribute guides or manuals of diagnostic methodology.
6. More work should be encouraged for the production of rapid diagnostic kits and for the development of controlled long lasting release systems for mineral delivery. It would contribute to improve the diagnostic, prevention and treatment of mineral deficiencies in food producing animals to compare with conventional methods.

7. As limited bibliographic information is available in developing countries, special attention should be given by FAO to assist the research groups to get actual selected references on nutritional diseases of food producing animals. This action could be done in connection with the Networks under a periodical system.
8. FAO should assist the countries to produce Extension Manuals to distribute to farmers with practical information and recommendation about mineral deficiencies, mineral mixtures, ways of supplementation and/or administration of minerals, feeder devices, etc. to apply to extensive production systems predominant in the developing countries.

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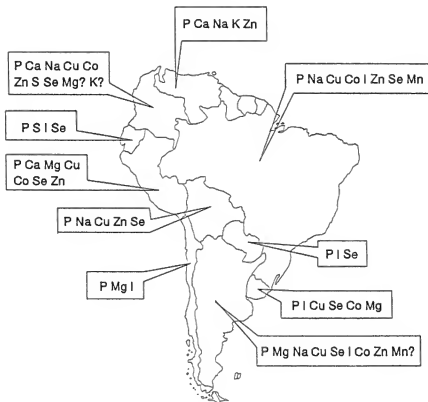
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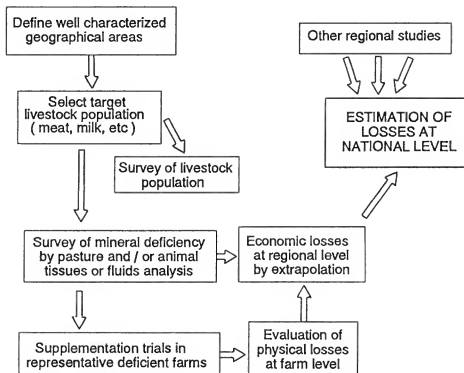
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MINERAL DEFICIENCIES REPORTED IN LATIN AMERICAN COUNTRIES



PROPOSED SCHEME OF APPROACH TO EVALUATE ECONOMIC LOSSES DUE TO MINERAL DEFICIENCIES



FOOD LOSSES DUE TO NUTRITIONAL AND METABOLIC DISEASES AND PROGRAMME FOR THEIR REDUCTION

by

D. Magic^{1/}

The Agriculture in the majority of developing countries is the main source of subsistence for their population and the main source of their national incomes.

The rapidly increasing population in developing countries requires a substantial increase in agricultural output. There is no doubt that technological changes are necessary if the food demand of mankind is to be met. However, it is necessary to determine the types and levels of proposed measures. They must be applicable to given conditions, and the extent and rate of their possible absorption has to be defined.

The objective of this paper is to identify the priority causes of the animal production losses caused by imbalanced nutrition in developing countries and to suggest a way to solve the problem.

Objective: Animal Production to Genetic Potential

A. <u>Optimal way to achieve:</u>	B. <u>Present Situation in developing countries</u>
1. Fertile soil	1. Soil Fertility - declines
2. Sufficient production of plants (forage)	2. Lower plant production of poorer nutritional value
3. Sufficient supply of feed for animals	3. Insufficient supply of feed for animals
4. Correct feeding systems to bring nutrients of the feed to the animal organism	4. Lack of appropriate feeding systems (traditional, extensive under nutrition, malnutrition) of livestock
5. Healthy animals	5. Animal production - declines

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- | | |
|---|--|
| 6. Animal production to genetic potential | 6. Health disorders of animals, diseases caused by nutritional deficiencies, metabolic diseases |
| | 7. Further decrease of animal production - losses of food of animal origin |
| | 8. Weakening of animal organism. Higher incidence of infectious and invasive diseases, higher morbidity and mortality rates. Higher food losses. |
| | Objective: Reduction of Food Losses |

COMMENT ON PRESENT SITUATION IN DEVELOPING COUNTRIES

B.1 Decline in soil fertility

In developing countries a number of archaic and unproductive agricultural practices used constitute the real assaults on the environment. Deforestation, flooding, erosion and desertification are, in the vast majority of cases, the result of overexploitation of fragile lands by peasants who have no choice of methods (1).

Only since 1968, one-fourth of the grazing land located in semi-arid regions of Africa - the major source of meat supply to the continent - has been lost to production. Rainfall has diminished since 1968. More recently, the greenhouse effect has resulted in general climate warming thereby increasing the risk of drought. Africa has little soil comparable to the rich silty deltas of Asia or the basaltic soils of South America. Without fallow land or manure, the soils contain increasingly less humus and are becoming completely impoverished (2).

However, it must be remembered that the soils, i.e. of the Sahel, would have high agricultural potential if the drought-prone climate were more favourable. The cereal harvest of 8.9 million tons in 1988 in that region has proved this. It was nearly 30% more than in the previous year (3).

B.2 Lower plant production of poorer nutritional value

Pasture is the main source of energy and other nutrients for livestock in developing countries. Quantity and quality of pasture depends upon the fertility of the soil.

In arid zones, seasonal changes of forage production as a result of irregular rainfall patterns and drought lead to severe changes in the availability of animal feeds (23). It is generally assumed that the total forage production from grazing lands is rapidly declining (20).

Macro and micronutrients are important for healthy plant growth. Deficiency or decreased availability of macro and micronutrients for plants decreases forage production.

The results of an FAO study, aimed to identify a general picture of micronutrient status of soils on a worldwide basis, show the locations throughout the developing countries where deficiencies of most of the micronutrients can be suspected. Certain countries and regions revealed particular deficiencies (4).

Forages grown on tropical soils have been shown to be highly deficient in a number of macro and micromineral elements needed by the animal. Phosphorus, Ca, Na, Co, Cu, I, Se and Zn are most likely to be lacking. In some regions, under specific conditions, Mg, K, Fe and Mn may also be deficient (5).

There are great variations in the vitamin content of forage mainly due to severe seasonal changes of climate. There is a drastic decline of carotene in pasture during prolonged droughts (18). Thus, vitamin A deficiency is not only a problem in animal feeding, but has become a serious public health problem in Africa, the Americas, Asia and the western Pacific (22). Data on the nutrient content of potential animal feeds have been collected in respective developing countries.

The nutritional value of forage depends on interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate. These factors have to be taken into account when planning a survey on the nutritional value of plants in some regions or countries and, of course, when evaluating such data. From the practical point of view, it is important to calculate with the nutrient content of feeds possibly being influenced by the above mentioned factors.

B.3.4 Lack of animal feed resources and lack of appropriate feeding systems causes imbalanced nutrition (undernutrition and/or malnutrition) of livestock

Cattle owners in developing countries have very similar feeding systems utilizing pastures, crop residues, pasture regrowth after burning and tree browse as main cattle feedstuffs.

Because of the high density of livestock, overgrazing results in severe nutritional penalties (7, 13). Tree fodder as one of the traditional sources of animal feed is often the only green feed available in the dry season (8).

The main constraints to pig and poultry production within developing countries include scarce feed resources, mainly due to the competitive nature with humans (10). Only 20% of the agricultural output is further processed for feeding purposes.

Insufficient feed supply is further complicated by inappropriate feeding systems and inadequate management practices (8, 10, 11, 13). Under such conditions the animal nutrition is imbalanced because of undernutrition (lack of energy) and/or malnutrition (lack of respective nutrients).

Low livestock production, limited by genetic potential, declines further because of inadequate nutrition (9, 11, 12, 13).

The major limitation is energy intake which, under typical tropical conditions, is severely restricted by the poor quality of feed mainly during the dry season. Then it is heat stress which causes a reduction of feed intake.

B.5,6,7 Animal production declines - body nutrient reserves are being depleted - animal health disorders such as metabolic diseases and those triggered by nutritional deficiencies occur. They cause a further decline in animal production and food losses.

Gaps in productivity per animal between developed and developing countries have always existed. However, in Africa for example, it seems to have been a tendency for productivity in terms of beef and milk output per animal to decline between the 1970's and 1980's. This has widened the gap not only between developed countries and Africa, but also between Africa and the average for developing countries (8).

Continued imbalanced nutrition combined with nutritional strain during critical biological phases of the animal, such as pregnancy and lactation, lead to breakdown in the animal homeostasis. Body reserves of respective nutrients are being depleted and metabolic disorders take place. Breakdown of homeostasis leads to the clinical signs of metabolic disorders (17).

Nutrient deficiencies caused by imbalanced nutrition are thus the cause of animal health disorders diagnosed later as "metabolic disease" or "disease caused by nutritional deficiencies". The term "production disease" as a part or synonym of metabolic disease is being closely related to metabolic disorders of high performance animals. Heavy drainage of nutrients via milk, for example, is the primary cause of metabolic disorders. Many of the various clinical conditions embraced by this term include well-known metabolic problems such as milk fever grass tetany and ketosis. Others are less well-known and some are so insidious and poorly defined that they go unrecognized. They include pica illthrift disappointing milk yield infertility and various skeletal abnormalities. In developing countries it is mainly a problem of herds of high-producing imported dairy cows, with variable feed intake, especially when pasture is the sole source of feed (18).

Simple, monoetiological metabolic disorders occur very rarely. Conversely, combined polyetiological disorders are frequent and their incidence is increasing.

Mineral and vitamin nutrition disorders range from acute deficiencies or toxicities, characterized by well-marked clinical signs and pathological changes, to mild and transient conditions difficult to diagnose and expressed as vague unthriftiness or unsatisfactory growth and production. These latter conditions are of great importance because they occur over large areas and affect a large number of animals.

B.8 Weakening of animal organism, higher incidence of infectious and invasive diseases, higher morbidity and mortality rates. Higher direct losses.

The economic importance of metabolic disorders of farm animals depends on the frequency of their occurrence.

Metabolic disorders not only produce considerable direct losses, but they substantially negatively affect production, reproduction, the biological value of the products and, not least in importance, they render the organism more susceptible to infective and invasive diseases (16).

The "food losses" due to primarily imbalanced nutrition, which is very common, are without any doubt very heavy. Quantification is, however, rather difficult because of lack of relevant data throughout the developing countries.

The result of the Malawi CTVM Project directed to identify the causes of cattle losses have shown that malnutrition probably caused higher losses of livestock than any infectious disease (19). The data collected over the years in Mozambique aimed at identifying the factors which negatively influenced small ruminants' health and production have revealed that undernutrition and consequent weakness were among the most important causes of losses (23.8%). An additional 26% of deaths were of unknown etiology.

It is difficult to separate the lack of feed from those of other factors of losses, most notably invasive and infectious diseases. It is clear, however, that hunger and sickness are inseparable. Thus, the additional 26% of losses might be accounted for either under and/or malnutrition as well.

Strong ecological pressure is exerted by cattle feeding in terms of use of pasture areas and water. Cattle need mobility and dispersion while the pasture areas are limited because of drought. As available pasture dries up and the cereal supply becomes limited and dearer, the opportunity cost of live animals increases considerably. Moreover, weakened livestock is subject to epizootic diseases, particularly rinderpest.

The decline in the national herds during the drought years of the 1980's amounted to almost 20% in Cape Verde, 33% in Botswana, 37% in Niger, and 55% in Sudan. The livestock fecundity rate declined by 60% in Mali. In Lesotho, the proportion of total mortality directly attributable to drought, and thus to undernutrition, is estimated to have been as high as 50 - 60% for cattle and 20 - 30% for sheep and goats during the past five years of drought. Milk yields in this country dropped between 1982 - 1984 to 30 to 60% of normal levels. In Burkina Faso, the Government had to pursue an active livestock destocking operation covering 16,000 head as a means of ensuring ecological relief, and most of these animals were sold to neighbouring countries. In Niger, the government encouraged livestock owners to sell their cattle before dying from thirst and hunger.

The livestock situation in drought-stricken LDCs improved with the rainfall increase in 1985 (Burkina Faso, Chad, Mali and Niger). The condition of the livestock population, however, has continued to deteriorate in several LDCs owing to the poor pasture as a result of dry weather (Botswana, Djibouti, Somalia) and to plagues of insects (Sudan, United Republic of Tanzania).

RECOMMENDATIONS OF METHODOLOGY AND ACTION TO BE TAKEN TO REDUCE FOOD LOSSES DUE TO NUTRITIONAL AND METABOLIC DISEASES

Philosophy of recommendations

1. The measures taken must be complex. It is clear from the schedule presented that there are very close links and interactions among the respective points of the "food chain". The goal cannot be fully achieved unless the actions directed to improvement are taken at each point in the appropriate order.
2. The measures proposed must be applicable to the existing conditions of the region concerned, and should thus be flexible.
3. Great importance must be paid to the awareness of the population concerned. They should be informed that the aim of the project introduced is not essentially the introduction of new technology, but the remedy of their problem, i.e. reduction of food losses.
4. The measures of the project should be discussed to an appropriate extent with the decision-makers and the farmers of the country or region concerned.
5. The introduction of the latest advanced technology is seldom the best solution and the use of locally available practices and experiences is often more successful. Traditional knowledge is fundamental. Discouraging traditional production systems leads to a break in the transfer of knowledge.
6. The plant cover is a function of the locality. If quality of forage has to be improved, i.e. if the botanic composition has to be changed, then the fertility of the soil has to be improved or the locality changed. The same applies for livestock raising. Without existence of necessary conditions there is no desirable animal production.
7. The correct allocation of financial resources needed to reach the main target is essential.
8. Whatever the type, standard and extent of measures or technologies chosen to reduce losses and enhance productivity of livestock, they should also attain the following objectives: provide jobs for the people, encourage the development of non-agricultural activities in rural regions, provide a sufficient increase in the incomes of small farmers, provide an increase in quantity and improvement in the quality and stability of food sources for rural families, improve the skills, experience and conscience of the rural population, bring about changes in the social and institutional structures and contribute to the steady development of production activities. Technical constraints remain a major impediment to livestock development. One of the primary aims of the veterinary profession is to seek and implement technical solutions to livestock production.

The solutions should be directed at the following groups: quantity and quality of animal feed and nutrition; inadequate management practices; genetic potential and animal health and disease problems.

It is necessary to stress the fact that the attention of veterinary and other animal science professionals in developing countries was directed mainly to the solution of animal health and disease problems. The same is true with activities of many professional teams in developed countries assisting in the improvement of animal production in developing countries.

After solving many problems of disease prevention and control, it is now time to pay more attention to management constraints relating to both technical and resource utilisation.

Optimal nutrition of animals is an essential precondition for the reduction of food losses due to nutritional and metabolic diseases

In developing countries it is more appropriate and realistic to call for optimal nutrition of livestock to the possible extent under the existing environmental and climatic conditions.

The measures to be taken to ensure the needed supply of feed for livestock

1. Soil fertility improvement and/or conservation as a precondition of good forage yield

(a) Irrigation when feasible

- utilisation of many existing local, traditional systems.

(b) Enrichment of the soil

- application of organic animal manure and green manure
- application of fertilizers.

Non-rational plant nutrition is one of the main causes of the backwardness of agricultural production in developing countries. Nutrition itself contributes 40 - 50% to the increase of the output of crop production.

Optimum utilization of fertilizers in the crop production systems of tropical agriculture is one of the priority factors for intensification.

For the 90 developing countries covered by the FAO study "Agriculture: Toward 2000", the growth rate in fertilizer use is projected at between 7.5 and 8.5% per annum. There are many results confirming the positive effect of the application of correct doses of fertilizers on crop yield.

- application of new advances in soil sustaining biotechnology (breeding for increased biomass, protein quantity and quality of plants, N-fixation, etc.).

(c) Development of soil management systems to avoid soil degradation

- alley cropping and other forms of agroforestry
- minimum and zero tillage methods.

2. Improvement of grazing lands, development of permanent pasture, utilization of crop residues, fruit and vegetable wastes for animal feeding

The factors needed to ensure optimal supply of nutrients to livestock are as follows:

1. The existence of data on nutrient requirements of animals;
 2. The existence of data on nutritional value of respective feeds available;
 3. Application of at least reasonable feeding techniques and systems.
- 1.1 There are some data on nutrient requirements of native ruminants. There are data on nutrient requirements of imported animals, both ruminants and non-ruminants. Meanwhile, for formulation of feed rations these data can be used for native breeds as well. More research is needed to obtain data on nutrient requirements of livestock raised in the tropics.

- 2.1 (a) There are extensive data on the nutritive value of most tropical and subtropical feeds. Those in a short run can be used for diet formulation.

It is a well established fact that many nutrients of the feeds may be influenced by composition and fertility of soil, climate and cultural practices. Great errors can be made if temperate-zone data on feeds are used in the tropics. For this reason further investigation on the nutritive value of respective feedstuffs in respective countries, even respective regions of the country, are necessary.

- (b) There is a great seasonal difference in the nutrient content of forage. This is true mainly for the content of protein and vitamins. Digestibility of nutrients is diminishing with the maturation of plants. This must be taken into account when sampling the plants and formulating the diet.

- 3.1 Improvement of the efficiency of feeding systems and technologies.

To reduce food losses caused by low livestock production, the high-yielding and high input technology from developed countries was introduced. The results are not always fully satisfactory. One practical option is to generate a technological package in cooperation with producers, capable to fully utilize the available resources and increase the efficiency of the existing production systems.

- 3.2 Regardless of the standard of feeding system applied, it must be stressed here that formulation of rations for the animals or for the herd is necessary. The farmers or animal holders must be made aware of the essential basic tools of proper feeding and nutrition.

4. Improved management practices that lead to improved animal production will necessitate more attention to **mineral nutrition**.

- 4.1 **Adequate intake of forages** by grazing ruminants is essential in meeting mineral requirements.

- 4.2 Application of **indirect** (use of mineral fertilizers) and **direct administration of minerals** (in water, mixtures and drenches, rumen preparations and injections).

- 4.3 The designs of mineral feeders should be very simple. All age classes of animals must be able to reach the supplement.

There is evidence that the realisation of the above-mentioned approaches in developing countries brought about a positive impact on the health status and production of livestock.

5. The veterinary service has to realize preventive blood chemistry analyses for screening livestock herds for nutritional or metabolic diseases.

Medium-term and long-term strategies

A. The major technological problems faced in developing countries in reducing the food losses caused by imbalanced nutrition include:

1. Agricultural research, 2. Feed supply, 3. Disease control.

- 1.1 One priority for **livestock research** is to work out applicable feeding technologies where local practices and skills have to be utilized to increase the efficiency of existing production systems.

Research should move from narrow disciplinary interest to problem-solving research under field conditions.

- 1.2 Nutritional research should concentrate on:

- (a) investigation of nutrient requirements of native, crossbreeds and imported livestock;
 - (b) analyses of nutritive content of animal feeds available, with special emphasis on non-traditional feeds;
 - (c) application of advances in biotechnology of plant and animal nutrition and production;
 - (d) development of applicable methods of forage conservation (haylage, silage) under different tropical conditions.

- 2.1 **Feed development strategies** vary with ecological zones. The important lines of development for improvement of the feed base comprise improvement of pastures, utilization of crop residues, fruit and vegetable wastes for animal feeding. Production of concentrated feed mixtures, mineral, and vitamin supplements for animal nutrition has to be increased.
- 3.1 To establish productive and profitable livestock enterprises, risks due to not only infectious but **nutritional and metabolic diseases**, must be kept at a minimum. The operating funds allocated by governments to **veterinary services**, which are in many countries inadequate for even the minimum animal health coverage, must be increased.
- 3.2 To prevent and diagnose nutritional and metabolic disease, the application of the system of metabolic profile tests have to be worked out.

The great advantage and importance of the new concept of metabolic profile tests is not only the improvement of a system of preventive medicine, but also the pressure on improvement of feeding systems.

B. Education and training

The well trained livestock and veterinary service personnel of all levels are essential to accomplish the task of reduction of food losses caused by imbalanced nutrition.

Veterinarians have held most, if not all, of the leading positions in the livestock and veterinary services in developing countries. The medical part of a profession must, in future, be combined with a much wider realization of political, economic, social and environmental spheres. Veterinarians must take into account the economic factors which must be more **manageable**. Animal feeding and nutrition is one such field. Veterinary professionals must be more manageable in the future. Knowledge of veterinary medicine prepared them not only to take care of animal health and food hygiene, but also to search and realize the ways to minimize the adverse effects of difficult policy environments.

This approach has to be present in undergraduate and postgraduate veterinary education and training. Education and training of auxiliary staff is essential.

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FOOD LOSSES DUE TO NUTRITIONAL AND METABOLIC DISEASES AND PROGRAMME FOR THEIR REDUCTION

by

Soontaranee Tongyai^{1/}

SUMMARY

Very little information is available concerning nutritional and metabolic disease prevalences with various reasons: (1) multiple factors involved in animal health problems and greater concern over infectious diseases and parasitism; (2) inadequate diagnostic laboratories to provide detailed studies of any occurring diseases; (3) insufficient number of veterinarians to cover health service work and specialized laboratory/diagnostic work. Thus, the information available on nutritional and metabolic disease prevalences only showed mineral deficiencies, seasonal malnutrition and protein-energy imbalances as main problems in livestock production. The impact is greater on animal health status, work performance, productivity and disease susceptibility than the loss of animal lives. However, it can be noticed that the main common factors in all farming groups lie in the inadequate knowledge and understanding of animal holders concerning nutritional management as part of production and health management under various stress conditions (climatic stress, nutritional stress, etc.). Economic expansion and industrialization of animal production could lead to greater nutritional and metabolic problems if the appropriate intervention programme is not undertaken. Several strategic plans are proposed to step-up public awareness, knowledge and concern.

INTRODUCTION

Asian countries are progressively changing from agricultural countries into agro-industrial countries. One of the main agro-industries being emphasized is the animal meat and animal product industry, not only for national consumption, but for world supply. Thus, production of livestock, poultry and aquatic animals is expanding towards medium- to large-scale industrialized farming, replacing small-scale individualized farming. The control factors of the rate of such expansion are:

- quality and quantity of crop production for animal feed source (as well as human food source) in relation to land for crop cultivation;
- animal breed;
- diseases;

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- technology and know-how in animal production and management.

In the face of the increasing demands for animal protein sources due to both the expanding human population and growing *per capita* purchasing power in Asia, animal productivity is considered low, especially cattle and buffalo meat production and reproductive performance. Efforts to raise productivity through genetic improvement programmes have been advocated. However, improvement of animal health, nutrition and management is still desirable before the benefit of the genetic improvement programme can be fully manifested.

In focussing on disease prevalences in previous years, infectious diseases and parasitism were, and still are, of major concern. Metabolic and nutritional diseases which, although receive less attention due to sporadic occurrences and lack of information, could turn into major problems if technology and know-how in the management system do not progress parallel to the livestock production expansion.

LIVESTOCK PRODUCTION BACKGROUND

Looking into the present situation of metabolic and nutritional problems, certain variations occur in the type and degree of problems among animal species and the different farming systems:

- (a) small-holder farming;
- (b) cooperative farming;
- (c) medium- to large-scale industrialized farming.

In Thailand, the livestock population is distributed at varying densities among the four regions of the country (Table 1). All of the Swamp buffalo population (*Bubalis bubalis*) are owned by small-farm-holders and serve principally as draught power for crop cultivation (rice, cassava, etc.), transport, meat and manure production. They are highly concentrated in the north-eastern plateau where the rainy season giving an average rainfall of 1,300 mm/year is followed by over six months of harsh dry season.

Native cattle are mostly raised as an asset to the household and, to a lesser extent, for transport work. At present, high quality beef cattle are being introduced to small-farm-holders for meat production improvement. High quality beef cattle production, although still low to meet the consumption rate, is mainly in the form of cooperative farming and medium-scale farming.

Most of the country's dairy cattle (95%) are raised in cooperative farms in various parts of the country, while 5% belong to medium- and large-scale industrialized farms.

Most pig and poultry production is industrialized in medium to large-scale farming and only a minority belong to cooperative and small-holder farming. Native chickens are also reared mainly for household consumption and supplementary income by small-holder farmers.

Table 1. Livestock population and distribution in Thailand (Agricultural Statistics of Thailand, 1989)

Animals	Population (million)	Regional Distribution (%)			
		Northeast	North	Central	South
Buffalo	5.44	74.9	15.1	7.2	2.8
Cattle	5.28	36.1	25.0	24.7	14.2
Pig	4.68	22.6	18.8	49.3	9.3
Dairy cattle	0.10	5.0	9.0	75.0	11.0
Sheep	0.13				*
Goat	0.08				*

* Area mostly raised

The majority of sheep and goats are raised in the southern part of Thailand by small-farm-holders. The herd size of each holder is expanding with increasing interest and market demand. This could lead to industrialization in the near future.

For the animal health service, four governmental regional diagnostic centres are located in the northern, north-eastern, central and southern parts of Thailand. Four provincial hospitals for economic livestock and poultry owned by three university veterinary faculties provide additional public services, but the diagnostic laboratories attached to the hospitals still require expansion to reach standard levels. Ratios of veterinarians per unit livestock given in Table 2 show the high workload borne by the Asian veterinarians to give any desirable results in the veterinary services.

Table 2. Workload of veterinarians in different parts of the world (Information Centre of the Ministry of University Affairs, Thailand)

Country/Region	Veterinarian : Unit Livestock Ratio*
Japan, Korea	1 : 622
Europe and America	1 : 3,097
Thailand	1 : 11,413
Asia	1 : 14,248

* Unit livestock calculated from 1 animal : 1 unit for buffalo and cattle; 1:0.4 for pig, sheep, goat; 1:0.01 for poultry

PREVAILING PROBLEMS

Compiled results from several investigations, reports and observations indicated that mineral deficiencies, seasonal malnutrition and protein-energy imbalances are the main nutrition/metabolic diseases occurring at varying degrees among the three farming systems and the animal species.

Problems in small-holder farms

Animals raised by small-holder farmers are more affected by infectious and non-infectious diseases and parasitism due to the way they are raised, i.e. they find their own feed or whatever is available for them to eat. Therefore, during the dry season when feed is scarce and only low quality rice straw is available, their health conditions worsen.

During the dry season, severe emaciation and signs of body protein degeneration detected by blood biochemical analysis were often found without clinical signs in cattle raised by small-holder farmers, notably in the north-eastern provinces. Interestingly, buffalo raised under the same condition manifested various clinical signs from difficult gait or non-inflammatory lameness due to stiff limb(s) (Sarataphan *et al.*, 1982a; Sondee *et al.*, 1988) to postparturient hemoglobinuria or red water disease (Sarataphan *et al.*, 1982b). The common findings in these reports were severe hypophosphatemia whereas Sondee *et al.* (1988) also found moderate to severe hypocupremia with or without hypophosphatemia in most cases (Figure 1). Although no mortality rate was found, this affected the use of these animals for draught power. Locomotion problems (lameness) in buffaloes occur widespread in the northeastern region especially in the year of severe drought and the signs disappear after the onset of the rainy season when the animals are able to find more feed. In analysing the plasma randomly collected from non-lame animals, mild hypophosphatemia and/or hypocupremia were also found. Although the cause of the lameness is inconclusive, the results seem to indicate an aggravation effect of poor nutritional status on mild mineral deficiencies already existing.

In 1986, Leidl *et al.* reported cases of seasonal nutritional myopathy or "Tetanoid Syndrome" in buffaloes in the northeastern provinces which responded to vitamin E and selenium treatment. Neither hypocupremia nor hypophosphatemia were found. The morbidity rate was 32% of at risk animals in affected herds with a mortality rate of 8%.

Several factors play a role in relation to disease prevalences in small-holder farms. The effect of climatic and soil conditions on feed supply and animal health status in terms of growth rate, disease susceptibility and reproductive performance (conception rate and calving rate) is well known (Figure 2). Knowledge, understanding and interest of the animal owner have been shown to be important factors in getting superior performance by improving the body condition of the animals during the crucial period of the late dry season (Leidl *et al.*, 1989).

In the livestock development project with emphasize on self-help programmes launched by the Veterinary Volunteer group from the Faculty of Veterinary Medicine, Kasetsart University, (Tongyai and Wongnarkpet, 1989), it was noticeable that animal health status could be improved by knowledge and basic technology transfer to increase better

understanding in animal production and health management and to overcome local beliefs and superstitions. However, the success of any development programme relies on the level of household interest and community concern. Moreover, continuous guidance and cooperation of local animal health officers are essential for programme continuation on a long-term basis as animal holders tend to resume their previous ways once they feel that they are being neglected.

Problems in cooperative farming

Animals raised in cooperative farms receive better care than those in small-holder farms but still some health problems appeared as a result of inadequate understanding by animal holders of herd health management.

Protein-energy imbalance is often encountered in cooperative dairy farms relating to economic expansion, feed price elevation and feed substitution for cost reduction. The usual practice in member farms of many cooperatives in calculating daily feed supply is based on milk:feed ratio. Thus, with low quality feed and inappropriate protein-energy source, a gradual drop in milk production led to a further reduction in the feed supply resulting in emaciation, severe milk production reduction and poor reproductive performance without records of any important mortality increase. This reflects inadequate understanding in dairy cattle management.

Mineral deficiencies also appeared in certain risk areas in the form of severe hypocupremic anemia. Hypocalcemic recumbancy with a drop in milk yield by half in all affected dairy cows (DLD unpublished case report) was encountered in 17 households of one dairy cooperative farming in southern Thailand. These animals were fed pineapple waste throughout the dry period. At the beginning of the rainy season, the problem manifested clearly with one death in a mature animal and one pre-natal death.

Problems in medium- to large-scale industrialized farming

To date pig and poultry production, giving good short-term income, received great care, thus, showing negligible nutritional or metabolic diseases. Problems exist mostly in the dairy business where purebred dairy cattle are imported for high milk productivity. In certain farms, a combination of inadequate knowledge in herd health management system and insufficient feed availability to supply large-scale farming resulted in low milk production and poor calving rate in such high potential dairy cows.

Thus, in all, knowledge, understanding and concern of animal holders must be greatly accentuated to get better health and production results. To do so, sufficient diagnostic laboratories and information centres for public services and trained veterinarians or animal health officers for effective treatment and prevention or control programmes play key roles.

FIGURE 1 BUFFALO LAMENESS AND MINERAL PROBLEMS
NORTHEAST THAILAND (SONDEE ET AL 1988)

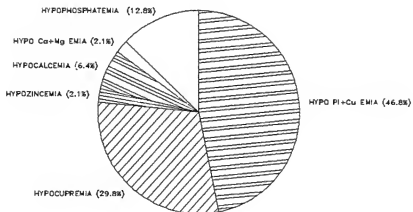


FIGURE 2 MINERAL STATUS IN NON-LAME BUFFALOES
NORTHEAST THAILAND (SONDEE ET AL 1988)

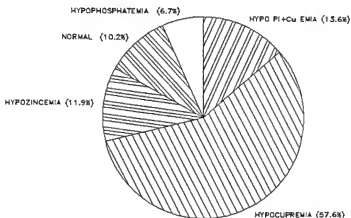
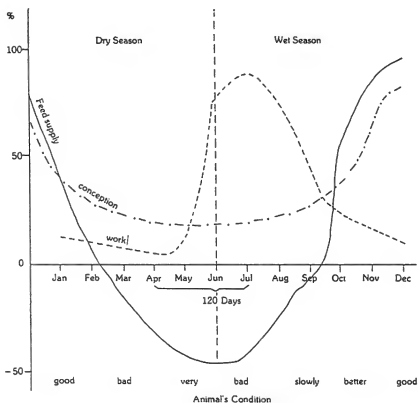


FIGURE 2 Interdependence of feed supply, animal condition and conception rate (Scholtz *et al.*, 1989)



PROPOSED STRATEGIC PLANS

1. Diagnostic laboratories and methodology set up for routine biochemical, haematological and microbiological tests and post-mortem studies for public service, data assembly and statistical analysis of disease occurrences and predisposing factors involved. This would provide information for the effective treatment and prevention and control programmes which include herd health management, production and promotion of proper and quality controlled feed and mineral supplements.
2. Provide special training or refreshment courses and/or workshops for veterinarians and animal husbandry workers.
3. Emphasis on the disease problems and losses for public knowledge and concern in the form of: educational programmes through mass media (TV, radio, newspaper, etc.), primary to high school supplementary education, scientific presentations or special talks and publications, cooperative or livestock association meetings and/or workshops, farm extension services in the form of self-help programmes in basic health care and management.
4. Set up a research centre, information centre and national and/or international network gathering additional information from the diagnostic laboratories.
5. Establish close linkage between governmental institutions and the private sector.
6. Increase the production of veterinarians/year.

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FOOD LOSSES DUE TO GENETIC DISEASES AND PROGRAMME FOR THEIR REDUCTION

by

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SUMMARY

Genetic resistance to disease can be identified usually as a polygenic quantitative trait in livestock populations that may be amenable to selection using molecular and quantitative genetic methods combined with embryo cloning and transfer to accelerate production of improved livestock. Such an approach to livestock health is appealing in the African context because the alternative traditional disease control methods have not provided solutions to the prevalent disease problems which contribute to productivity deficits of animal protein. It is conceivable that indigenous or semi-indigenous cattle could be the subject of sophisticated breeding programmes designed, not only to address the immediate needs for more productive healthy livestock, but also to establish wealth generating breeding industries serving the tropical world from tropical bases. The feasibility of using indirect selection methods based upon disease resistance-linked phenotypic and genetic markers is described and the potential of the approach is discussed in the context of African trypanosomiasis.

INTRODUCTION

Disease prevention by vaccination, vector control, antibiotics or chemotherapy is effective in many instances, but even the most advanced versions of these methods have not yet provided solutions for the most complex of host-parasite interactions. A discouragingly large proportion of the unresolved human and animal health problems occur in the developing countries. In many instances, the diseases in question reflect a negative balance between several virulence genes and their products from various types of pathogens and a correspondingly diverse inventory of host resistance-mediating attributes, also under complex genetic control. Viewed in this way, the problem becomes one of redressing the balance in the genetic interplay between host and parasite. A number of non-infectious diseases also occur in which susceptibility is genetically controlled. In contrast to susceptibility to infectious disease, these usually reflect traits associated with single rather than multiple alleles. In both instances, however, frequency of the susceptible phenotypes may have been increased because of co-segregation of linked productivity genes.

During co-evolution of host- and parasite-resistance and resistance-evasion mechanisms, progression is expected from pathogenicity through commensalism to symbiosis (Mitchell, 1991). For any given species or breed, the status of this progression varies for a particular parasite and resistance system. Genetic variation in disease resistance and susceptibility has

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been recognized historically, but in contrast to variation in productivity, it has been little utilized in improving livestock (Lie, 1990). For this reason, and because of a desire for environmentally safe disease control methods, there is increasing interest in exploiting genetic variation for prevention of economically important diseases (Gavara, 1990).

While the developed countries struggle with overproduction, the underdeveloped regions face escalating protein-energy malnutrition due to inverse interaction between population growth and food production. In sub-Saharan Africa (SSA) population increases 3.1% annually while meat and milk production grow at only 1.4% and 2.3% (de Haan, 1991). Annual livestock mortality loss in the SSA is US\$ 2 billion and equivalent losses are estimated for reduced fertility, growth and work. By the year 2000, imports of 2-5 million tons of meat and 10-15 million tons of milk at an annual cost of US\$ 15 billion will be required (de Haan, 1991).

Since productivity deficits are attributed in part to inadequate livestock health support systems, strategies for enhancing productivity through genetic manipulation of livestock will need to address, not only the biological, but also the socio-economic and political realities of the target regions. Ideally, novel solutions will simultaneously resolve issues of animal protein deficits and establish new opportunities for income-earning livestock industries. It is conceivable that, to meet the urgent needs of developing countries for animal protein, sophisticated genetic strategies and methods will be established placing tropical countries in a position of market strength internationally as suppliers of tropically-adapted livestock.

DISCUSSION

1. Defining the Problem

Two broadly different situations can be identified, each of which may find solution in host genomic manipulation. Genetic predisposition to disease may be defined in terms of a single event involving host susceptibility to a specific disease or it may be regarded more broadly as a problem of general disease susceptibility or resistance.

While it is intuitively appealing to consider diseases individually, this could result in actions which may be counterproductive. For example, in chickens the major histocompatibility gene allele B²¹ is associated with resistance to Marek's disease and can be used as a genetic marker for this trait but at the risk of simultaneously enhancing susceptibility to Rous sarcoma (Simonsen, 1987).

Similarly, porcine enteric disease due to K88 adhesin antigen-positive *Escherichia coli* does not occur in K88 receptor-negative pigs. However, receptor expression is dominant and homozygous recessive dams, which do not permit gut colonization with K88 positive bacteria, fail to produce K88-specific antibody for lactogenic transfer to offspring leaving them susceptible to K88 positive *E. coli* if they are progeny of susceptible sires (Hanset, 1982). Also, since K88 is only one of several *E. coli* adhesins, resistance to K88 positive organisms does not impart resistance to other enteropathogenic *E. coli* expressing different adhesins.

In mice selected for antibody production to complex antigens, susceptibility is increased to intracellular pathogens (Mouton, 1985). This observation reflects the dichotomy which generally requires antibody to resist extracellular pathogens and cell-mediated resistance mechanisms to counter intracellular pathogens. Resistance of cattle to *Brucella abortus*, a facultative intracellular pathogen, is apparently a function of macrophage activity and is inversely related to antibody response, although it is linked to antibody of the IgG₂ isotype (Tempelton, 1990). Although macrophage function could be used as a marker of resistance to brucellosis, increasing population frequency of this trait may engender risk of increasing susceptibility to other diseases for which antibody response is the principle resistance-mediator.

Specific, as opposed to general disease resistance, may be an acceptable objective if it can be achieved without enhanced susceptibility to unrelated pathogens, if a single disease can be unequivocally identified as the principal target, if alternative methods are unavailable or if the resistance-mediating trait(s) are unique to the target disease and are obscure. The prion-induced disease of sheep, scrapie, and by analogy, spongiform bovine encephalomyelitis, may warrant attempts to establish specifically resistant stock. In sheep, resistance to most, but possibly not all, strains of the scrapie agent is a function of a single locus Sip, at which an allele designated sA dictates susceptibility when homozygous or heterozygous with an allele pA. The homozygous genotype pA/pA is associated with resistance to scrapie in flocks selected for low scrapie mortality and this phenotype can be predicted on the basis of polymorphism in cleavage of DNA by restriction endonucleases (restriction fragment length polymorphism, RFLP) (Hope, 1990).

Since it is unusual for livestock populations to be at risk from a single disease, a more usual problem would be to enhance general disease resistance. Since the fundamental reason for controlling disease is to enhance productivity, the objective of disease resistance, especially in the developing countries, must not be at the expense of production. In some cases, genetically induced disease is linked to productivity. Genetic susceptibility to malignant hyperthermia/porcine stress syndrome, an autosomal recessive production disease of pigs, is associated with desirable carcass quality (Davies, 1988). Genetic resistance to bovine mastitis is inversely related to milk production (Solbu, 1990) and the neurological condition, "weaver", genetically recessive in Brown Swiss cattle, is associated with enhanced productivity (Hoeschele, 1990). The implications of these, and similar potentially confounding relationships for genetically-based control programmes, must therefore be carefully considered.

To exploit genetic methods for control of disease it is necessary to first identify a genetic basis for disease and/or resistance to disease. It is generally accepted that disease resistance and susceptibility are polygenic traits controlled by additive quantitative trait loci (Lie, 1990). In this regard they are like most production traits and should be amenable to biommetrical strategies for selective breeding which may be conducted with or without actual knowledge of the underlying genes or gene products in molecular terms (Georges, 1991). Immune response in mice selected for high or low antibody production is controlled by at least ten loci and heritability of the trait is 0.20 ± 0.08 with 53% of total phenotypic variation due to genetic factors (Biozzi, 1984).

In some instances, polygenic traits, including disease resistance/susceptibility in livestock, involve major genes which may provide a significant proportion of variation such that the quantitative trait has a high heritability and segregates within the population in Mendelian fashion (Hanset, 1982). Infertility in Shorthorn cattle due to reproductive tract anomalies ("white heifer disease"), double muscling in cattle and the Hal⁺ gene in pigs all behave as major genes or major gene-controlled traits (Hanset, 1982). The Hal⁺ gene is recessive, has high penetrance and contributes 60%, 20% and 20% to variance in meat quality, back fat and proportion of ham as well as determining, when homozygous, the occurrence of porcine malignant hyperthermia (Hanset, 1982). The linked gene for glucosephosphate isomerase (GPI) can be used as a genetic marker for Hal⁺ (Davies, 1988) which itself is likely to be a mutant Ca²⁺ release channel encoding gene, possibly the gene for the ryanodine receptor (MacLennan, 1990).

Given knowledge of the physiology of disease resistance or susceptibility, it may be possible to identify associated candidate genes known to have relevant products or to be sufficiently closely linked as to segregate with the quantitative trait loci of interest such that they may be detected by RFLP analysis, or other genetic methods, as an aid in selective breeding (Beckman, 1987). Rapid progress in molecular genetics and continued evolution of population genetics as well as developing sophistication in understanding host parasite resistance mechanisms, provide opportunity for pragmatic programmes for livestock health based upon genetics. Most of the required methods are already available and the principal challenge is to apply them under developing country conditions. The objective will be to identify animals with desirable health-related phenotype and to disseminate this phenotype widely within regions, countries and continents.

2. Methods of Possible Relevance to Genetic Control of Livestock Disease

Methods are required for identification of useful phenotype, correlated phenotypic markers, associated genotype and genetic markers, propagating the desirable type and disseminating it in the target regions. Attention must be given to the animals and to the infrastructure in which they will be developed and used. The planned programme should be far sighted and be closely integrated with long range economic goals as well as with more short range objectives.

If possible, the proposed actions should include at the outset all of the partners who will eventually be involved in its functional exploitation such that regulatory, social and economic compatibility may be ensured. An ideal programme will provide substantial self sufficiency to the user groups or countries and allow them to develop wealth based on intellectual and real property arising from the development programme. That is, the developing countries involved in a programme to produce livestock having improved genetically-based health characteristics should be placed in a position to gain, not only from local use of the livestock but also from potential markets for the animals, the knowledge and the skills developed in producing them. Technology transferred to the developing regions in pursuing these objectives should be incorporated into a viable local infrastructure capable not only of sustaining local requirements for improved livestock but also of enhancing productivity in similar areas elsewhere in the World.

The methods employed will involve integration of advanced quantitative genetics to identify desirable traits and to estimate their heritability, molecular genetics to provide genetic markers of desirable alleles and possibly to map the relevant gene loci and techniques of embryo transfer including sexing, cloning, freezing and transportation to facilitate propagation and to minimize phenotypic assessment (Bettridge, 1989, Kennedy, 1990, Georges, 1991, Barnes 1991).

If a specific disease or diseases have particular significance, biological knowledge of pathogen and host-related resistance phenotype and genotype will be important as a basis of refining the general approach. For example, in providing tests of relevant host resistance traits and genotypes that may be employed in selecting foundation stock for improvement and for monitoring phenotypic and genetic progress. It is at this point that genetic approaches to animal health overlap with more conventional programmes involving development of diagnostic tests and vaccines. There is, in fact, a high level of synergism between the two approaches. Although programmes to develop vaccines against complex organisms, such as trypanosomes, may not yet have been entirely successful they may well have identified enough host and parasite-related factors of influence in pathogenesis and host resistance that these could be used in determining useful host phenotype. If relatively resistant or susceptible host phenotypes could be derived on this basis these would be simultaneously useful in production systems and in experiments to further refine vaccine and diagnostic technology. It is the population low response extreme that is problematic in vaccine-based programmes, therefore, laboratory efficacy trials using this subgroup should better indicate useful vaccines. Alternatively, a vaccine that is unable to protect random bred animals may nevertheless be efficacious in genetically defined populations developed concomitantly with the vaccine(s). In this way, flexibility may be provided such that in low risk situations the inherently disease resistant livestock may be productive without additional intervention, while in high risk conditions vaccination may be warranted.

Strategies for obtaining disease resistant populations may be contemplated if there is sufficient genetic variation and heritability of the resistance trait(s) (Gavora, 1990). Schemes may utilize direct selection based on observed health status of naturally or experimentally infected animals or involve phenotypic or genetic markers significantly linked to the disease resistant phenotype (Lie, 1990). Direct selection is presumed to operate in populations in enzootic areas if intervention does not favour survival of susceptible individuals subsequently used in breeding programmes. For deliberate breeding of resistant animals direct selection has the advantage of identifying resistance resulting from the effects of many genes and corresponding resistance mechanisms, even when these are poorly understood and cannot be measured. It is, however, impractical since it may only be conducted in areas of enzootic infection, where it depends upon survival of potentially valuable stock and puts stock at risk. Infection and disease are not readily standardized, therefore complicating assessment of genetic variation. Determination of disease resistance phenotype may only be possible in relatively mature animals contributing to the relatively high costs of direct selection schemes. A further disadvantage is that direct selection pertains to a single condition and does not have the potential of providing broadly based population resistance to a variety of diseases.

Indirect selection, especially when based upon a spectrum of host resistance-related phenotypes covering divergent virulence mechanisms, is preferable. If phenotype and/or linked genetic markers are critically assessed for relevance in the target breed, they can

provide easily standardized tests applicable in any location without risk of disease. Genetic markers may be used in marker assisted selection, possibly on early embryonic cells, to identify the preferred genotype for introgression into populations having other desirable attributes such as productivity or heat adaptation. If *in vitro* fertilization of fetal oocytes becomes technically feasible it may be possible to identify desirable genotype using appropriate gene probes in conjunction with the polymerase chain reaction and to skip generations of adult animals thereby accelerating genetic progress towards desirable phenotype (Betteridge, 1989), a process referred to as "velogenetics" (Georges, 1991).

Transgenes are unlikely to contribute to production of genetically disease resistant livestock in the near future since it is not feasible to transfect simultaneously several genes, or to have transfected genes insert into appropriate, predetermined positions in the recipient genome. With better definition of major genes contributing to host resistance and refinement of homologous recombination methods (Baker, 1988), transfection may contribute.

3. Indirect Selection for Disease Resistance Using Resistance-related Phenotypic and Genetic Markers

Indirect selection may be based upon measured resistance-related traits and correlated markers, such as the major histocompatibility gene (MHC) products (Batra, 1989), in known linkage with resistance-mediating mechanisms. In this way natural or artificial infection is avoided together with related requirements for standardized infection methods, objective quantitative criteria of disease, infection containment and control. Indirect selection criteria may be chosen which offer low risk to potentially valuable breeding animals and which may be utilized without confounding effects from variable individual infection and acquired resistance status. Resistant populations could therefore be derived in remote locations in which it may be impractical to work with exotic pathogens.

The question of whether or not indirect selection may be used to enhance disease resistance has been addressed in a series of experiments using pigs. Pigs were chosen for their fecundity and availability of MHC (SLA)-defined miniature pigs (Sachs, 1976). Methods were evaluated which may have broad relevance in livestock breeding. These experiments have been reported and also briefly summarized (Wilkie *et al.* 1990). Two general approaches were taken. The first involved evaluation of immune and innate-resistance related traits in pigs of four SLA haplotypes (SLA^{A*,C*,D*,E*}) in all homozygous and heterozygous genotypes. The g haplotype is a recombinant (Thistlethwaite *et al.* 1983) having SLA class II genes of d and class I genes of c allowing analysis of the relative effects of these SLA genes. Haplotype, sire, dam, litter and other effects were determined by linear general model and least squares analysis while heritability was calculated by the SAS VARCOMP procedure (Helwig and Council, 1982). In another study, Yorkshire pigs were selected using Estimated Breeding Values (EBV) calculated using restricted maximum likelihood under an individual animal model (Henderson, 1984).

To assess immune and innate resistance-related functions standard protocols were used to induce and measure primary and secondary antibody to hen egg white lysozyme (HEWL), sheep erythrocytes (SRBC) and (T,G)-A,L; serum IgG and IgM concentration (by radial immunodiffusion, RID), serum lytic complement (CH50), cutaneous delayed hypersensitivity (DTH) to PPD of *Mycobacterium tuberculosis* (Bcg), cutaneous contact allergy (CH) to

dinitrochlorobenzene (DNCB), *in vitro* blood lymphocyte blastogenesis to concanavalin A (con-A) and PPD and cultured blood monocyte function in uptake and killing of *Salmonella typhimurium* and *Staphylococcus aureus*. Antibody and cell-mediated immunity (CMI) to a *S. typhimurium* aromatic mutant were also determined. The purified O-polysaccharide of the parent *S. typhimurium* was used to determine lymphocyte blastogenic and passive haemagglutinating antibody. Antibody avidity was measured by a chaotropic ion (KSCN) elution system in enzyme immunoassay for antibody to HEWL.

Results of Experiments in SLA-Defined Miniature Pigs

Antibody and Cell-Mediated Immune Response (Mallard *et al.* 1989a): Dam, sire and litter influenced immune response traits ($p \leq 0.12$ - 0.001 , 0.88 - 0.001 and 0.69 - 0.001 respectively) while SLA and sex had lesser effects ($p \leq 0.72$ - 0.01 and 0.95 - 0.02). SLA, dg, gg and dd formed a response group by rank but rank position varied by time after immunization. This group was superior in response to HEWL, (T,G)-A,L, SRBC and DH to PPD but low in ranked CH response to DNCB. Heritability was estimated for HEWL (0.81 - 1.17) and (T,G)-A,L (0.11 - 0.44) but not for SRBC, CH and DNCB due to negative sire variance. Heritability of DH response to PPD was 0.03 and 0.13 for 24 and 48 hour post challenge measurements.

Immune Response to *S. typhimurium* (Lumsden, 1989): Primary antibody response was influenced by litter ($p \leq 0.026$ - 0.0001) at various times after immunization but none of the variables included in the statistical model influenced secondary antibody response. Litter also influenced antibody response after challenge infection ($p \leq 0.0052$). There were no significant differences in antibody response by SLA haplotype although dd, cd and dg were usually highly ranked. For CMI, litter ($p \leq 0.011$) and sire ($p \leq 0.019$) influenced primary response at days 6 and 13 post immunization (pi) respectively while SLA ($p \leq 0.004$) and litter ($p \leq 0.026$) influenced secondary response on day 20 pi. Only litter influenced response after challenge ($p \leq 0.0001$). The effect of time by haplotype was significant ($p \leq 0.0002$) with dd, dg and gg being either higher or lower in ranked response than aa, ac, cc and cd at various times pi.

Serum Immunoglobulin Concentration (Mallard *et al.* 1989b): IgG concentration was influenced by sire ($p \leq 0.001$), dam ($p \leq 0.002$ and 0.02 for 24hr and 48hr RID), SLA ($p \leq 0.01$) and litter ($p \leq 0.02$ and 0.06 for 24 and 48hr RID). Haplotypes dd, dg and gg had very significantly more serum IgG than others and heritability estimates were 0.13 and 0.27 for 24 and 48hr RID. IgM concentration was influenced only by litter ($p \leq 0.001$ and 0.009 for 24 and 48hr RID) and heritability is assumed to be zero because of negative sire variance.

Serum Lytic Complement (Mallard *et al.* 1989c): Activity (CH50) was determined before and after immunization. Prior to immunization only litter and dam ($p \leq 0.03$ and 0.06) influenced the trait while none of the variables influenced post-immunization CH50. The average CH50 differed significantly ($p \leq 0.001$) pre- and post-immunization with a tendency for haplotypes other than dd, dg and gg to have elevated CH50. Differences between haplotypes were not significant. Heritability for CH50 was not estimated because of negative sire variance.

Uptake and Killing of *S. typhimurium* and *S. aureus* (Lacey *et al.* 1989): litter and SLA had significant effects on uptake and killing as measured at 4 and 8 weeks of age ($p \leq 0.0001$ for litter and $p \leq 0.0769-0.001$ for SLA in various assays) while sire did not contribute significantly. SLA behaved in group response fashion with dd, dg, gg and cc high or low in the rank order. An apparent effect of age was significant but subsequent studies suggest a cyclical effect with low response at 8 weeks, possibly due to weaning-related stress.

Antibody avidity and maturation of avidity between primary and secondary immune responses were not significantly influenced by SLA but were by litter ($p \leq 0.01-0.05$). Pigs of the dd haplotype had significantly greater avidity maturation than the others as did the dg and gg haplotypes although not significantly so (Appleyard *et al.* 1991a).

Results of Selection Experiments with Yorkshire Pigs: (Mallard *et al.* 1989d):

In the F_0 generation, sire and gender influenced primary response to HEWL ($p \leq 0.05$) but not to (T,G)-A,L while sire significantly influenced secondary response to both antigens. Heritability and genetic correlations were used to determine traits for inclusion in the selection index. These were HEWL antibody (day 21 pi), IgG concentration (day 0), DH to PPD (24hr post-stimulation), lymphocyte blastogenesis to con-A and killing of *S. typhimurium* by cultured blood monocytes. F_1 progeny of the H and L groups differed significantly for HEWL, con-A and PPD responses ($p \leq 0.03, 0.03$ and 0.007) as well as for the correlated traits SRBC and CH to DNCB ($P \leq 0.10$ and 0.01). IgG concentration and monocyte functions did not differ by selection group. Heritability values for combined F_0 and F_1 generations were 0.25, 0.23, 0.08, 0.08 and 0.00. Avidity of antibody to HEWL was not correlated with antibody quantity, however the H group had significantly ($p \leq 0.005$) higher average avidity than the L group (Appleyard *et al.* 1991b). At the third generation of selection the lines are significantly separated by EBV and for HEWL, con-A and PPD. Production characteristics also favour the high response line.

These results suggest that resistance-related traits can be influenced by selection using EBV and that MHC genotype has a variable influence which is generally less than other terms such as litter. It remains to be determined if there are differences in disease resistance between SLA haplotypes or between selected lines. The bovine major histocompatibility genes have been associated with a number of economic traits, including resistance/susceptibility to ticks, mastitis and bovine leucosis and the apparent contribution of the MHC loci to overall genetic variation may be sufficient to warrant their use as genetic markers in selective breeding (Barta, 1989).

4. Genetic Approaches to Control of African Trypanosomiasis

It is estimated that 10 million square kilometres of Africa are unusable for livestock production because of the tsetse fly and trypanosomiasis which it transmits (de Haan, 1991). The tsetse infested areas carry some 147 million cattle (ILRAD Report, 1989) and with control of trypanosomiasis it is estimated that an additional 33 million could be kept with corresponding production increase of 495,000 tons of meat and 537,000 tons of meat equivalent as milk. Given total annual production of 3,162 million tons of meat and 8,745 million tons of meat equivalent in milk, these represent gains of 16% and 18% respectively

(Msellati 1991). Thirty percent of African cattle are thought to be at risk from trypanosomiasis and losses in meat production alone are in the order of US\$ 5 billion annually (ILRAD Annual Report, 1989). Trypanosomiasis is the principal source of low productivity, 70 times less animal protein/hectare than Europe, in African cattle and small ruminants (ILRAD Annual Report, 1989). It is clear that effective control of trypanosomiasis would significantly enhance productivity and correspondingly reduce human malnutrition and provide new revenue as potential export sales of animal products and reduction in expenditures for importation of animal products.

The pathogenesis of trypanosomiasis is extremely complex and although much progress has been made towards understanding virulence mechanisms and host resistance attributes this has not yet resulted in availability of an efficacious vaccine. Likewise, although trypanocidal drugs are available, drug resistance is readily developed by trypanosomes. Control of the tsetse vector has also been problematic since it involves habitat modification and use of insecticidal traps neither of which reliably reduce vector numbers below the threshold at which new infections cease. Even if efficacious vaccines, drugs or anti-tsetse control systems were available it is unlikely that their advent would alleviate trypanosomiasis. This is in large part because of the declining standards of animal health delivery infrastructure (de Haan, 1991) which has resulted in failure to control diseases such as rinderpest for which useful vaccines have long been available (ILRAD Annual Report, 1989).

The *Bos taurus* breed, N'Dama and others such as the West African Shorthorn, are known to be relatively resistant to African trypanosomiasis having been bred in enzootically infected locations for some 5 - 7 thousand years in contrast to *Bos indicus* breeds and European *Bos taurus* animals which are susceptible and highly susceptible, respectively, having been in Africa for periods of approximately a thousand and one hundred years (ILRAD Report, 1989). The N'Dama represents only 5% of cattle in the tsetse infested countries (ILRAD Report, 1989) and is the subject of extensive experimentation aimed at defining the extent of its trypanotolerance, its heritability, phenotypic correlates and productivity (ATLNL Annual Scientific Report, 1990). Since the doubling time for N'Dama is estimated to be 15 years (A. Teale, 1991) it is apparent that extraordinary measures are needed to effectively utilize even the average level of trypanotolerance available in present unselected N'Dama.

In comparisons with the susceptible Boran breed, the N'Dama is found to have lower parasitaemia at a given infection level with trypanosomes, to more rapidly reduce parasitaemia after infection, to produce IgG₁ antibody to a 33 kilo-Dalton trypanosome invariant antigen and to produce little IgM antibody to irrelevant, non-protective antigens, to resist development of anaemia and to have earlier and more sustained lymphocyte mitogenic response to trypanosome antigens after infection. Anaemia is apparently due to destruction of erythrocytic precursors by activated monocytes in the bone marrow and possibly to autoantibody (ILRAD Workshop, 1991). The blood erythrocyte packed cell volume (PCV) may be used to indicate disease following trypanosome infection of cattle and PCV has an estimated heritability of 0.35 (Trail, 1991).

An indirect selection programme for trypanotolerance could well be undertaken in the N'Dama breed based upon estimated breeding values for phenotypic markers of resistance to trypanosomiasis. These may include amount, rate and avidity of IgG₁ antibody production

to the isolated 33kD invariant antigen and possibly indices of monocyte activation, IgM production to trypanosome "irrelevant" or other antigens, such as bacterial lipopolysaccharide. A measure of lymphocyte blastogenesis would be included using a trypanosome antigen or other inducer of cell-mediated immune response such as *Bacillus Calmette Guérin*. High and low response lines could be bred using these criteria in a manner analogous to the Yorkshire pig experiments described above. Such lines would further facilitate identification of genes associated with trypanotolerance (Soller, 1976) and if major genes were mapped these could be used in marker assisted selection and gene introgression to accelerate development of trypanoresistant populations by "velogenesis" (Georges, 1991). This approach could as well be taken with tropically adapted breeds having high productivity in non-trypanosome enzootic locations such as the Jamaica Hope breed in the West Indies. This would have theoretical and practical advantages since there would not be confounding effects of variable individual exposure to trypanosomes which could introduce environmental effects into variation observed in Africa. Also, it may relieve somewhat the requirements for selecting on the basis of productivity which would be concomitant in the N'Dama breeding programmes.

A consortium of local breeders, breed associations, commercial breeding and embryo transplantation companies, as well as veterinary and animal breeding research institutes supported by private, governmental and agency funds, could undertake a selection programme such as that described here. If advanced embryo technology, quantitative genetics and molecular biology were utilized throughout the programme a nuclear infrastructure would be established to support ongoing livestock improvement programmes. It is conceivable that improved tropically adapted breeds would result which could be the basis of an export industry to sustain tropical livestock production globally. In this way an ecologically sound solution would be provided for a major animal health problem and possibly general enhancement of disease resistance and productivity would be attained to alleviate inadequate human nutrition while establishing a wealth generating industry in the developing world.

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FOOD LOSSES DUE TO NON-INFECTIOUS REPRODUCTIVE DISEASES AND PROGRAMME FOR THEIR REDUCTION

by

Galina, C.S.^{1/}

INTRODUCTION

Reproductive disorders are one of the most important causes of reduced productivity in livestock. Poor reproductive performance is responsible, for instance, for almost 40% of cows culled in farms in developing countries. The severity of the disorders is associated, among other things, with the method of farming (extensive or intensive farming, poor or efficient management), location of the farm, breed of the animals and the type of reproductive programme carried out. As a consequence, not all of the recommendations made in this paper will be equally applicable to the different ecosystems and management conditions found within the developing countries.

Nevertheless, it is possible to divide cattle enterprises in developing countries into two major groups: those located in the highlands (usually more than 800 metres above sea level) and those found in the lowland, tropical and subtropical regions. Advantages and constraints are usually different in these two distinct geographical areas. Although a variety of farming methods are found within these regions, it is generally true to say that dairy cattle in the highlands, mainly Holsteins, are managed under intensive and semi-intensive dairy farming systems whereas beef cattle in these same areas are generally reared using more extensive farming methods, the most popular breeds being those of European origin, such as Hereford or Angus.

In the case of cattle raised in the lowland tropics, the systems geared towards the production of dairy products, or a combination of dairy and beef, are usually organized on a limited budget, comprising Zebu derived breeds crossbred with European stock, particularly Brown Swiss and Holsteins. However, the increasing popularity of dual purpose systems has created in many countries useful examples of semi-intensive systems. In the case of beef cattle, particularly in Latin America, the industry has successfully implemented modern technology, such as artificial insemination programmes and embryo transfer.

Reproductive Problems In Intensive Units

(a) Failure to detect oestrous signs in dairy cows

In those intensive enterprises where artificial insemination is a common procedure, the single most important factor that influences reproductive performance is probably

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the single most important factor that influences reproductive performance is probably accurate detection of oestrous. In developing countries this situation is usually aggravated as farmers, in many instances, do not allocate the time and personnel needed to perform this task with accuracy. In a recent survey which sampled a wide range of Mexican farms (Anta *et al.*, 1989), the accuracy of oestrous detection was found to be 39%. There are many practical problems that contribute to this poor efficacy: (a) farmers do not usually set themselves targets or standards in their herds and oestrous detection is reduced to "the task that needs to be done whenever there is time available"; (b) this situation is worse when the technicians in charge of the enterprise (veterinarians, agronomists and related professions) are not aggressive enough in identifying the problem early in the heifer programme or in the postpartum period; (c) lay personnel in charge of oestrous detection have a poor grasp of the knowledge available on the behavioural signs of oestrous, thus limiting their observations to only those cows that exhibit homosexual riding behaviour.

There is a lot to be done in organising courses for farmers, technicians and laymen to disseminate recent knowledge on 1) methods of oestrous detection, 2) the use of pharmacological agents to enhance expression of oestrous and 3) reproductive herd programmes aimed at monitoring the ability of farmers to identify cows in oestrous early in the breeding programme.

(b) Hormonal disturbances in cattle

Most of these problems have been associated with high-yielding cows, and there are only a few selective areas in the developing countries where cows produce more than 6000 litres per lactation. Because of this limitation, cystic ovarian disorders, a common feature among high yielding cows, are often poorly diagnosed and treated in developing countries. Uterine infections account for irregularities in the oestrous cycle, and empirical treatments for these conditions are often more of a problem than a cure. This is particularly important in countries where treatment of cows is a routine procedure as a consequence of poor training in veterinary schools.

Although, in everyday practice, veterinarians in the developing countries diagnose many problems (e.g. delayed ovulation after onset of oestrous, anovulatory cycles, persistent corpus luteum and many others), research has shown that the incidence of these is indeed rather low. Again, as reproductive programmes with a set of objectives are becoming more frequently applied by a more popular feature among technicians in the developing world, it is important that these abnormalities in the oestrous cycle be appreciated and tackled directly.

(c) Repeat breeding syndrome

This is probably one of the most important causes of reproductive failures in cattle raised under intensive systems in the developing world. It is estimated that 20% of the cows submitted to an artificial insemination programme do not conceive after three inseminations in spite of having regular oestrous cycles. The causes for this reproductive failure are related to genetic and nutritional factors, poor insemination technique, uterine infections, climatic factors, biochemical changes in the uterine environment and endocrine imbalances. Although the importance of these effects is fairly well documented in the industrialised world, there

is little research in countries in the developing world. Anta *et al.* (1989) observed that in 16 years of published information in Mexico, only 20% of the data available on cattle reproduction were related to dairy cows. Moreover, less than 10% of the data available in dairy cows addressed the problem of failure of the cows to conceive following insemination. Thus, it is not surprising to find that official figures for this syndrome are not accurate and the magnitude of the problem has not been complemented by research in the area. As failure to conceive following artificial insemination is a serious setback to the prosperity of a farm, it is important that scientists in the developing world spend more time and resources in investigating the causes of this failure.

(d) Heat stress in dairy cows

Although this problem bears a more intimate relationship with European cattle raised under tropical and subtropical conditions, nevertheless there is ample evidence that cows farmed under arid and semi-arid regions suffer a substantial decrease in fertility when submitted to high ambient temperatures, usually in the summer months. The magnitude of the problem remains to be accurately measured, although there is evidence in the literature that conception rates in the summer months can go as low as 20%. Moreover, the percentage of cows showing overt signs of oestrous can be drastically affected. These two effects, low fertility following insemination and failure to detect cows in oestrous, tend to concur in influencing the reproductive performance in the herd during the time when ambient temperatures are above 30°C.

Finally, the situation with respect to semi-intensive units populated by *Bos taurus* derived breeds is rather similar. Additionally, European cattle raised under these conditions, particularly in the humid tropics, have low survival within the farm and tend to be culled early. Vaccaro (1990), in an extensive review of the literature on the subject, has indicated that *Bos taurus* cattle imported into the tropics of Venezuela will not reach a second calving in almost 80% of the herd. Crossbreeding has not been a simple solution either. It has been well documented that cattle with more than 75% of European blood are stretched to perform adequately in developing countries where the rigid conditions of the tropics affect their ability to express the full potential of their genes. As this is an area of considerable debate between scientists and government authorities with respect to the policies of milk production in the tropics, FAO could assume an interesting role in screening published information and opinions offered in many international fora in order to be able to play a decisive role in the matter.

Reproductive Problems in Semi-intensive Units

(a) Nutritional status of the cow

It has been said that reproduction is a luxury function and poorly-fed animals will have a difficult time to reproduce adequately. As farmers in the developing world have serious problems in producing a constant food supply, it is not surprising to find poor nutritional status of cattle as a major setback to the reproductive efficiency of the herd. This situation is usually aggravated when farmers depend solely on products closely related to the rainy season and can offer little or no supplementation during the dry season. As this has been a usual problem in developing countries, studies in which scientists have tried to

identify constraints in animal reproduction have always noted that year-to-year variation in the rainy season precludes the drawing of firm conclusions as to a policy to establish, for example, the choice of a breeding season. In the past, semi-intensive units were programmed to have a low economic investment with a modest income from selling meat or milk. Therefore, reproductive programmes were kept to a minimum as there was not an immediate economic pressure to become more efficient. However, in many countries, demand for land from the less affluent sectors of society has created the need for farmers to become more efficient in the use of the land. Therefore, it is not unusual to find excellent examples of adequate supplementation, or even better, good management decisions in the use of improved pastures. As a consequence of these shortcomings, professionals involved in the sector of animal health and production have an important challenge in front of them, that of assisting farmers in planning strategies to maintain cattle in a good plain of nutrition based on the skillful use of the local resources.

(b) Lactational anoestrous

In a recent review, Galina and Arthur (1990) found that there are at least six different methods to reduce the effect of suckling on the onset of follicular development and ovulation in semi-intensive units. Research has shown that, under the present conditions, cows that are allowed to be suckled will not start their regular oestrous cycles until about 100 days after calving. This situation is usually aggravated when the body condition of the cow is poor due to inadequate nutrition. Consequently, strategies to keep calves under artificial feeding have become popular. Obviously, in areas within the developing countries, constant health hazards are a major burden on the offspring. Thus, research is needed in order to become more efficient in adequate rearing systems applicable under these conditions. Alternatively, farmers mostly dedicated to beef production have applied ingenious methods to partially reduce the effect of suckling. For cattlemen interested in the use of artificial insemination, the use of drugs to synchronise the oestrous cycle of cattle has given promising results although research is needed to clarify the causes of low fertility following insemination. Recent knowledge has indicated that postpartum anoestrous will be more of a problem in cows calving for the first time. Thus, in these animals, it is extremely important that they become pregnant early in the breeding season. Adequate management decisions are important in order to ensure that this happens. Potentially, there is a lot of room for improvement in our knowledge on how to handle the effect of suckling on the onset of ovarian activity.

(c) Failure to detect oestrus signs

Oestrous detection techniques in semi-intensive units have peculiar problems that need to be taken into consideration. As cattle spend little or no time under confinement, the intensity of behavioural oestrus can be rather low. Consequently, the time dedicated to such task needs to be intensified. Unfortunately, in my experience, this concept is not well understood among the users of artificial insemination. Concomitantly, technicians in charge of organising a breeding programme, in many instances, are not trained to use a sound clinical approach for making good use of reproductive records nor are they taught to administer drugs to manipulate the oestrous cycle. In general, they fail to make adequate use of the commercially available aids for better oestrous detection.

In recent years, research has shown that behavioural signs of oestrous are rather different in cattle under semi-intensive systems as compared to the traditional intensive units. This is particularly important in cattle derived from Indian breeds where the hierarchy in the herd plays an important role in oestrous expression. As the popularity of artificial insemination increases, there will be more demand for adequately trained personnel, especially in semi-intensive units.

Reproductive Problems in Extensive Units

(a) Lactational anoestrous

It is fairly obvious that the same problems outlined in the section for semi-intensive units are applicable for cows raised under extensive systems. Nonetheless, in these cattle, a system to artificially raise calves is seldom seen and most of the efforts to reduce the effect of suckling have been directed towards restricting the presence of the calf to short periods of time (partial weaning). Extensive units usually concentrating on beef production present difficulties in implementing a programme to reduce suckling for long periods of time and the norm is to allow the calf to spend all the time with the dam until weaning. As a consequence, the body condition of the cow quickly deteriorates and it is not unusual to find intervals from calving to conception longer than six months and in cattle managed under a restricted breeding season, cows calving in the herd every other year. The economic loss for this failure is fairly high and researchers should spend time designing strategies to overcome this problem.

(b) Bull to female ratio in breeding programmes

In spite of the growing interest in artificial insemination in developing countries, cattle raised under semi-intensive and intensive systems are usually bred by natural mating. Surprisingly, there are very few studies that systematically test the ability of bulls to perform under extensive conditions. In a review on publishing trends on cattle reproduction in the tropics, it was estimated that in the last 20 years less than 20% of the information published is related to studies in the male. Thus, many of the policies related towards deciding the adequate bull to cow ratio are based on individual experience rather than experimental results. This situation is important, there is a good body of evidence to suggest that 30% of the bulls utilised in breeding programmes are not performing as expected. If average fertility for a bull in a three month breeding programme is about 85% and poor performers average about 35%, it is fairly obvious that the number of calves lost due to the inability of the bull to seek and mate cows in oestrous is considerable. As fashionable technology like embryo transfer becomes available in developing countries, it is not surprising to find researchers diverting their attention to these techniques rather than investigating the value of traditional, established systems that, if improved, could have a major impact on animal productivity. Therefore, it is fairly important that funding organisations spend time and resources evaluating this situation.

(c) Parasitic diseases affecting body condition

Most of this paper has dealt with the effect of management, climate and nutrition on reproductive performance. This division was not meant to minimise the importance of an

adequate sanitary programme in the herd. Moreover, it is surprising to find the reduced number of papers dealing with the effect of a heavy parasitic load on reproductive performance. As easier technology becomes available to monitor the body condition of the animal, no doubt many papers will observe a close relationship of these variables, particularly in areas where parasites are endemic. Again, research tendencies towards the 21st century in developing countries will be aimed at establishing the real value of the different components that affect reproductive performance. If scientists make important advances in the utilisation of local by-products to feed animals more efficiently and the health status of the dam is seriously affected, it is obvious that animals will be deficient in using the forage adequately. Diseases that affect body condition, like anaplasmosis, piroplasmosis, fascioliasis, gastrointestinal blood sucking parasites and others should be borne in mind when planning a reproductive programme.

RECOMMENDATIONS

Research

Scientists in developing countries should spend time building up baseline data on the causes that affect reproductive performance. There is ample evidence that cattle raised under intensive systems will have a calving interval of between 13 and 14 months but culling rate could be as high as 40%. Similarly, cattle raised under semi-intensive and extensive systems will have a calving interval of 14 - 16 months, with only 50 - 60% of the herd contributing to this figure. Age at first calving will be extended up to 40 months in *Bos indicus* cattle and about 30 months in *Bos taurus* breeds. However, the culling rate for the latter breeds could be as high as 60%. What are the reasons for these failures?

Governments and international organizations have supported research in developing countries but this has often been a thankless task. In a recent survey it was found that Latin American scientists working on cattle reproduction in the tropics publish papers for a period of about 2½ years on average. Consequently, when a young researcher learns the ropes of scientific research and writing, he or she tends to move to another job, disintegrating research groups and interrupting the continuity of research interests. Although there are valid reasons for young scientists to leave research, it is true that in many instances they find carrying out research in developing countries is not an easy task. Factors instrumental in the successful completion of projects are often lacking, such as facilities (buildings, laboratories and equipment), government incentives, a critical mass to comment on research proposals and to review papers before submission for publication, and understanding on the part of peers and administrators that research demands time and dedication and that researchers overloaded with administrative and teaching duties cannot be productive. Consequently, it is not surprising that scientists in less developed countries often find other occupations more attractive.

FAO should spend time and resources identifying individuals that, in spite of the above limitations, are willing to research into the major problems that limit production in their respective countries and to guide their interest towards finding mechanisms to solve these problems, i.e. financial, technical and administrative. Governments should support researchers by giving them facilities and incentives to continue in research rather than luring them to other administrative posts.

Teaching

Governments in developing countries, in general, have made the fatal mistake of opening schools of veterinary medicine, agronomy and related fields, without a previous plan of the number of graduates needed to work in animal health and production. As a consequence, students graduating nowadays are, in many instances, poorly prepared for research and professional duties. Veterinarians and agronomists alike are ill-equipped to manage livestock enterprises with the object of making them productive and economically viable. Consequently, the livestock industry is, in many cases, in the hands of "hobby farmers" that do not mind receiving low incomes from their enterprises as their main source of earnings lies elsewhere.

This situation will have to change as we move into the 21st century. As schools of veterinary medicine and related fields proliferate, due to social and political pressure, the only viable solution appears to be the founding of graduate schools that cater for recent graduates that feel the need to be better prepared for making a positive contribution in the field of animal reproduction. Therefore, FAO and other organizations should concentrate their efforts towards consolidating the few postgraduate programmes available in the developing countries. Continuing education courses should be a high priority in the teaching programme and encouragement should be given to graduates willing to return to academia to take formal and non-formal courses.

Extension services

To my knowledge, this is an area where developing countries are far behind the industrialized world. Mechanisms simply do not exist to convey recent research findings to the producer. Also, the general trend has been for experimental stations to develop research areas in accordance with their own interests, with little regard to solving the pressing problems that producers in the area are experiencing.

One interesting example relates to the supplementation of cattle to improve reproductive efficiency. It is fairly obvious that if a cow is poorly fed (a common situation in developing countries), supplementation will improve conception rates. Although this can be carried out in experimental stations where the budget is provided by the government, in many instances supplementation is not economically feasible for producers (especially the small community farmers) who are struggling for survival. Therefore, researchers should first diagnose what the problem is at farm level and then carry out research aimed at producing results that can be implemented by the producer in economical terms. Another example is the crossbreeding programme. There is ample evidence that the F1 product of crossing two breeds performs well. However, the next generation (3/4 x 1/4) usually renders erratic results. Are farmers going to adopt this technology when the economical situation in most developing countries is rather tight?

These two examples illustrate the fact that transfer of technology to farmers is not an easy task and international organizations working side by side with government authorities should draw up strategic plans to make sure that current technological developments reach farmers in such a way that (a) it is applicable under their conditions, (b) it is economically feasible, (c) it is easy to implement, (d) it is monitored through research.

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FOOD LOSSES DUE TO NON-INFECTIOUS REPRODUCTIVE DISEASES AND PROGRAMME FOR THEIR REDUCTION

by

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SUMMARY

Non-infectious reproductive diseases that adversely tax the productive potential of food producing animals are anatomical, functional, and of managerial origin. These also develop as a result of trauma/injury during, or following parturition, making way for secondary invaders to establish uterine disease. A brief summary of these etiological agents and the adopted pathways to cause reduction in food production has been suggested in the text.

The recorded information on the incidence of reproductive diseases among developing countries revealed that two forms of infertility that have the highest incidence are because of functional disorders and secondary uterine diseases that arise following trauma/injury at the time of parturition. Functional disorders which are of nutritional or genetic origin could be reduced by adopting appropriate nutritional management and selective breeding programmes. Uterine diseases (metritis, endometritis, pyometra) interfere with normal reproduction by delaying uterine involution causing either delayed onset of oestrous following parturition or through repeat breeding. In either case parturition intervals are prolonged which cause huge economic losses.

Introduction of proper records and education of livestock owners for better post-partum management, timely use of veterinary services and due attention to oestrous detection can markedly reduce the adverse effects of post-partum secondary infections. On the other hand, veterinary services need to be promptly available to handle all cases of obstetrical problems and properly treat the individual females that suffer from secondary uterine diseases (metritis, endometritis and pyometra). Launching of properly organized Sexual Health Control programmes at the level of small scale farms and for middle or large sized herds could yield definite reward in reducing food losses that occur because of reproductive disorders.

INTRODUCTION

Increasing human population in the developing world is continuously exerting extra pressure for enhancing the food production ability of its livestock. These present potentials of the developing world are far inferior when compared with similar animals of the developed world.

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The total food production capability of any livestock population (milk, meat and by-products) is directly dependent on her rate of reproductive efficiency and the rate of neo-natal survival and growth of her off-spring. Any disease or factor that will adversely affect these traits will simultaneously lead to decreased food production. In the developed world target levels for production related reproductive indices are well worked out and for dairy animals are as below:

Average age at first conception:	15 $\pm$ 1.5 months
Average calving interval:	$\leq$ 375 $\pm$ 45 days
Average open interval:	$\leq$ 90 $\pm$ 40 days
Proportion of herd culled for infertility:	$\leq$ 10% per year
Proportion of average herd not calving annually:	$\leq$ 5%

Comparable exact information on reproduction indices of livestock of the developing world is generally lacking, but it is agreed that these target levels are far more uneconomical and, as a result, these animals on average produce much less food.

In literature, infectious and non-infectious diseases/disorders have been described to adversely affect the fertility and production levels of livestock populations. In the developed world, with control/eradication of most well known infectious agents (Brucella, tuberculosis, vibriosis, trichomoniasis), the non-infectious diseases/disorders have become of significant importance in causing food losses. However, in the developing world these losses are still inflicted through both sources. Survey of literature further reveals that the non-infectious reproductive diseases could be of anatomical, functional and managerial origin and, in the event of various obstetrical problems at the time of parturition causing injury or trauma, may end up in secondary complications, mostly in the form of uterine diseases. A brief summary of the non-infectious reproductive diseases and the pathways through which they cause food losses or decrease in production is presented in Figure 1.

The total losses caused by these diseases/disorders are enormous both in the developing and developed world. The total costs involved result through the following contributory factors:

- (a) Sterility leading to increased culling rates (congenital/acquired).
- (b) Delayed puberty/maturation, decreased growth rate (nutritional and/or genetic).
- (c) Increased infertility because of depressed reproductive cycles and repeat breeding (nutritional, genetic, managerial, or non-specific secondary uterine diseases) leading to prolonged parturition intervals, fewer off-spring and increased costs of breeding.

- (d) Increased obstetrical problems leading to:
- loss of dam,
 - loss of off-spring or weak young ones,
 - reduced milk production,
 - increased uterine diseases leading to prolonged parturition intervals (obstetrical problems).
- (e) Increased pre-natal and neo-natal losses (management/obstetrical problems).
- (f) Increased costs of veterinary drugs/treatments for handling obstetrical problems (dystocia, prolapse of vagina and uterus, retained foetal membranes), secondary uterine infections (metritis, endometritis, pyometra, etc.) and diagnostic investigations (obstetrical problems/secondary uterine diseases).

DISCUSSION

Significant changes in the rate of factors causing infertility in livestock in developed countries have taken place in the last few decades. Control measures with large scale use of A.I. have resulted in control/eradication of most infectious reproductive diseases, like brucellosis, tuberculosis, vibriosis and trichomoniasis, resulting in their reduced importance as causes of infertility. As such, non-specific infections due to secondary pathogens have become of greater importance. However, the maximum food loss in these environments is because of poor management of herds. In this part of the world, based on dependable surveys, tolerable incidence of certain reproductive problems has been suggested as below (Morrow, 1980):

Retained placenta:	10%
Post-partum infection	
primary:	10%
secondary:	5%
Repeat breeding:	15%
Peri-embryonic deaths	
early (pre-pregnancy diagnosis):	9%
late (post-pregnancy diagnosis):	6%

Among developing countries, like India and Pakistan, several reports have become available on the percentage prevalence of reproductive diseases based on clinical data of dairy animals examined at various clinics for the treatment of these disorders. Narasimha Rao and Srceannarayna (1982), while working on 20,439 infertile dairy buffaloes, recorded that 2.5% of these animals suffered from anatomical defects, 73.77% had functional problems and 23.73% had non-specific uterine infections. On an individual problem basis, 56.36% suffered from ovarian dysfunctions and 20.68% had endometritis. In Pakistan, Samad *et al.* (1984) and Dhanani *et al.* (1987) also presented similar clinical data. Samad *et al.* (1984) reported that among 17,239 cases, 50.6% suffered from uterine infections (endometritis, puerperal metritis, pyometra and muco-and hydrometra), 35.9% were of ovarian dysfunction and 13.5% showed obstetrical problems. Dhanani *et al.* (1987), based on limited data,

recorded that 30.76% suffered from uterine disease (endometritis, pyometra), 9.99% had ovarian defects and 59.22% showed obstetrical problems (of which 34.61% suffered from retained placenta). From these quoted and other available reports, it could be seen that the frequency of reproductive diseases in developing countries differed from place to place. However, in all situations, two forms of infertility causing sizeable food losses were because of functional and non-specific uterine diseases.

Since functional and genetic diseases will be discussed in other papers, the present paper will concentrate mainly on reproductive diseases because of non-specific uterine infections and various aspects of management that will help in reducing these disorders and improve the post-partum breeding management. Several reproductive tract pathological conditions are acquired at or after parturition, as a result of trauma or infection, or both. Such produced lesions interfere with the future fertility of the females after causing significant decrease in their productive ability. These lesions have been reported for many years as a cause of sterility and infertility (Roberts, 1989) and mainly affect the uterus as forms of endometritis, pyometra, muco-metra, peri-metritis, uterine abscesses, sclerotic metritis and uterine tumours. It is agreed that most commonly encountered uterine diseases (metritis, endometritis, pyometra) are likely to follow abnormal parturitions such as abortion, retained placenta, premature births, twin births, dystocia and traumatic lesions or laceration of the uterus, cervix, vagina or vulva (Roberts, 1989, Arthur *et al.* 1989).

Uterine diseases are generally associated with delayed involution of the uterus, chronic uterine discharge, slow recovery of uterine endometrium and delayed conception, often associated with increase in number of services (Brus, 1954). The commonly recorded end results are either delayed onset of post-partum oestrous or delay in achieving conception because of repeat breeding. If diagnosed and treated early, most of these individually suffering females positively respond to appropriate therapy (Chauhan *et al.* 1984, Morrow, 1980).

In most developing countries, reliable data and recording systems are lacking and it is not possible to know the intensity of the adverse effects being caused by various non-infectious reproductive diseases. It is therefore recommended that reliable surveys at various levels be undertaken to fill this gap. Farmers/livestock owners can play a great role in reducing the incidence of infections associated with parturition. They need to be encouraged to maintain breeding records and ask for qualified veterinary services should the female require any assistance at the time of parturition, to decrease the risk of unnecessary trauma and subsequent infections. Veterinary staff, on the other hand, need to be fully qualified to handle these cases and should have the availability of necessary equipment, drugs and diagnostic facilities to properly attend the affected animals.

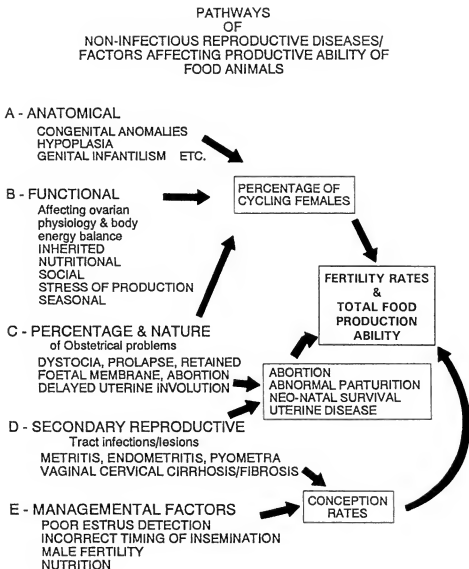
Maximum success in reducing the losses comes from the introduction of proper recording systems, on an individual animal basis, as required, for small-holders of the developing world as achieved by the Reproduction Clinics operating at Faisalabad and Tandojam (Pakistan). In this programme, farmers are taught the importance of heat detection and proper timing of insemination. They are also appraised of necessary hygiene required at the time of parturition and are encouraged to report all cases of reproductive disorders to veterinarians as soon as they observe them. This has helped extensively in the recovery of the fertile life of a large number of females suffering from these disorders, which otherwise

would have been rendered sterile. In areas where animals are kept in good numbers on a farm herd, simple recording systems could be maintained by the herd management. This helps to launch a proper sexual health programme on a herd basis and facilitates the management to properly observe animals that are coming to oestrous. Such a recording system, introduced in dairy farms in Uganda, comprising the completion of four monthly proforma, also gave the desired results. These proforma were for a monthly stock chart, individual record of breeding animals, monthly chart of all confirmed pregnant cows/heifers and monthly chart of breeding animals to be checked for oestrous.

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FIGURE 1



FOOD LOSSES DUE TO DISEASES RELATED TO TRANSPORTATION/TREKKING AND PROGRAMME FOR THEIR REDUCTION

by

Cheick Abagouro Bocoum^{1/}

INTRODUCTION

Food losses is a term subject to many interpretations. The purpose of this paper is to deal with the particular case of losses occurring in market livestock and meat in West Africa.

The production and marketing of livestock and related products is one of the largest and most important industries in tropical Africa.

In most tropical countries, capital and technical inputs are being directed towards increasing the production efficiency of the livestock population by increasing or improving quantity and quality of feed production, improved management, disease control, and breeding improvement. The net gains obtained in production by these efforts may be drastically offset by the losses incurred in moving livestock to points of processing and consumption. The net production of animal protein from any sector is a result of the yield of the animal production system, less the losses which occur through the marketing channel. These losses will affect the various segments of the beef industry, depending upon where, and to what extent, they occur. They will be reflected back to the producer in lowering the prices he is paid and will be costly to the trader and to the processor, limiting their margins and affecting the flexibility of the market for meat.

Historically, in Africa, livestock have been moved to urban markets by trek (on foot), but recently livestock have been shipped in trucks and by railroads because it was assumed that trekking resulted in large weight losses and often deaths. The growth of urban areas, with the increasing proportion of the population unable to supply their own food, has led to greater movement of stock from the producing to consuming areas. Since the distances involved are often very great, this movement has led to various effects such as shrinkage, bruising, crippling, mortality, carcass weight loss, change in carcass composition, etc. Consequently, transportation costs represent a large part of the total expense of marketing livestock.

Cost includes, not only the out-of-pocket cash paid for the transportation service, but also the opportunity cost of losses from death, bruising, crippling and shrinkage of the live animal, the deterioration of meat quality and carcass weight loss in transit.

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Governments and the private sector are concerned about the losses in marketing livestock and are interested in reducing such waste, but have little objective information at their disposal with which they can plan effectively. Unless reliable and accurate information is available, it is difficult to plan strategies to reduce these wastes and to improve production and distribution policies.

An understanding of factors influencing these losses, and the nature and effects of the losses, are necessary for governments' policies and businessmen's decision-making to reduce food losses.

At the present time, however, little is known about the nature and causes of losses occurring in market livestock and meat during the transportation phase in West Africa. The little that is known about these losses comes from economic analysis of transport as part of total marketing costs. Thus, data given in this paper should not be considered highly accurate. However, the information used is the best available to the author. Most of the material used in this paper is derived from the author's 1984 Thesis for the M.S. Degree submitted to Michigan State University.

The overall objective of this paper is to improve governments' and private sector understanding of food losses related to transportation and to recommend policies and strategies for minimizing food losses.

The specific objectives of this paper are:

- to describe and identify the nature and causes of losses occurring in marketing livestock. The topic of this paper dictates the use of a limited number of loss concepts which focus on five major classifications: livestock shrinkage, bruising, crippling, and death, and meat losses;
- to estimate the magnitude of losses for each system of transport;
- to identify current technology available in reducing losses for the purpose of making policy recommendations; and
- to identify research needed for loss reduction.

SHRINKAGE

Every farmer or trader knows that, in most cases, cattle weigh less when they reach final market than they did when they left the origin (farm, ranch or feed lot). Such loss in weight is called shrinkage. Shrinkage may take place while the animal is in transit, at the market, or in holding pens of the packers. When the shrinkage represents a loss in tissue weight (tissue shrinkage), it may be classed as a direct economic loss that affects the return to producers or traders, and it may be considered as a part of total marketing costs. When the shrinkage represents a loss of fill (excretory shrinkage), it constitutes a loss of live weight but does not change the weight of the carcass. However, excretory shrinkage can also be a loss to the trader if it affects the appearance of the animal and hence, its sale price if sold "on site" or on a live weight basis.

Thus, weight loss in livestock can be classified according to two types of shrink:

1. Excretory Shrink

The excretory shrink or loss of fill occurs when livestock are held off feed or water and when their health condition has deteriorated for a relatively short period. It takes a relatively short period on feed and water to refill the stomach and bring an animal's weight back to normal if shrinkage was due only to excretory shrink. During the shipment, the excretory shrink takes place at a rapid rate in the early part of the transit period. Maximum excretory shrinkage is reached after approximately 10 - 12 hours of shipment. During the latter part of the shipment, tissue shrinkage is relatively more important.

2. Tissue Shrinkage

Tissue shrinkage can be defined as a decrease in the carcass weight of the animal. It occurs on long extended periods of disease, hauls or during long periods of fast. It takes longer for animals to recover from tissue shrinkage than from excretory shrinkage. According to some experiments, live weight may be reduced by 10% of the initial weight after four days of starvation. However, starvation may not have any effect for the first three days but may begin to cause carcass weight loss by the fourth day. After eight days starvation, live weight losses were 15% of initial weight, and loss of carcass weight was estimated at 14%.

3. Factors Affecting Shrinkage

Factors that tend to affect the occurrence of shrinkage are numerous and they include both health and nutritional conditions. Thus, it is difficult during the transportation phase to isolate the impact of poor health conditions from poor nutritional or other stress-related effects on weight losses. It may even be more difficult to isolate the effect of non-infectious diseases from the influence of infectious diseases in weight losses during the livestock transitory phase. Some of the more evident factors of shrinkage during the livestock transport phase are: amount of fill, time in transit or distance shipped, disturbance of animals, temperature and weather (climate), animal health conditions and feed access during the transportation phase. Among these, the type of transportation and the animal health condition factors are the only ones which are relevant to this paper.

3.1 Shrinkage in Relation to Type of Transportation and Non-Infectious Diseases

Available data on shrinkage of livestock shipped on foot, by truck or rail, in West Africa are generally very scarce.

3.1.1 Trekking

In many parts of Africa, particularly in the western region, railways and motor roads have not yet penetrated the livestock producing areas. Thus, trekking is by far the most common means of moving livestock. Almost 100% of animals are moved on foot to domestic markets and about 50% of export animals are moved on foot.

Stock routes generally have been developed by traders but sometimes governments provide facilities such as water points, organization of grazing areas, and veterinary control posts along the routes.

M.G. Fenn found in marketing livestock and meat (about Africa) "on some very long and arduous routes, the loss in live weight can be 20% or more, representing a serious shrinkage of fat and tissues." Kellogg uses 2.5% live weight shrinkage per 100 miles approximately in his study. Mittendorf found live weight losses ranging from 15 - 30% in a study on the stock route from Upper Volta (now Burkina Faso) to Accra (Ghana) in 1952. For his part, Doutressoule found live weight losses ranging from 10 - 15% on a stock route from Mali to Ghana in 1950. OMBEVI (1978) reports a 5% loss of live weight for herds moving on foot in the dry season between Mopti (Mali) and Bouak (Côte d'Ivoire), a distance of 800 km. Dirck Stryker (1975) estimates live weight shrinkage at 10%.

No single cause of shrinkage has been established in all these studies because many causes may interact. One may speculate however, that part of these weight losses in trekking was due to some haemoparasitic diseases such as trypanosomiasis and gastrointestinal parasites (especially gastrointestinal strongylosis and fascioliasis).

3.1.2 Trucking

The movement of livestock in West Africa by truck is not well organized. There is no schedule of rates as on the railways, and charges vary according to supply and demand conditions. The main constraints to the extended use of this flexible and time saving method of transportation are the lack of good roads which reduce the effective life of a truck and makes its amortisation rates high, unpassability during wet seasons, and inadequate bridges. Therefore, road transport of livestock in West Africa is limited to short distances over good roads, especially in those areas where there is no rail line, or in response to a temporary shortage of livestock in a consumption market, or in the forest where trekking becomes difficult and costly because of the dense vegetation and heavy tse-tse infestation.

The shrinkage of trucked animals depends on the manner of transport management, the state of roads, truck shock absorber systems and speed, the load, and the conditions of the animals before the shipment. Poor roads, bad shock absorber systems and truck conditions increase considerably the jostling of livestock in transit which, in turn, may foster the shrinkage.

SEDES (1973) reports 10 - 20% of total costs per head due to weight loss in truck shipment from Mali to Côte d'Ivoire or to Ghana. John Staatz (1980) in "Meat Supply in Ivory Coast 1967-1985" estimates an average of 5 - 7% loss of carcass weight per head, an equivalent of 12 - 13% of total cost per head loss in a truck shipment of 50 head of cattle from Koutiala (Mali) to Abidjan, a distance of 600 km. In transporting cattle within Côte d'Ivoire

from Tingrela to Bouak by truck, Staatz reports 3.5 - 5.5% carcass weight loss per head. Earl Duane Kellogg (1971) reports in his Nigerian survey that an average of 30.7% of the total per head cost is due to truck shrinkage cost.

In addition to the jostling, part of the shrinkage of trucked animals is due to non-infectious diseases before shipment. Because of the relatively shorter period of the shipment, gastrointestinal parasites such as gastrointestinal strongylosis may cause the greatest losses attributable to non-infectious diseases.

3.1.3 Rail Transportation

The railway is used, in general, to ship cattle long distances and meet short term and seasonal fluctuations in demand. However, the percentage of livestock handled by rail is declining in all lines due to the frequent unavailability of livestock cars and also to the long time, averaging 3 - 4 days, that livestock spend in transit without feed or water between the time they are loaded and when they are unloaded at final destination.

The level of rail shrinkage depends on the manner of transport management, but also on the conditions of the rail cars, availability of facilities for feeding and watering, the time in transit, and the condition of the livestock before shipment. According to Herman (1978), the carcass weight loss is estimated at 10% per head on the rail trip from Ouagadougou (Burkina Faso) to Abidjan. This 10% is equivalent to about 16% of the animal purchase price. Staatz (1979) estimates 9% loss of carcass weight for the Ouagadougou-Abidjan trip. According to Kellogg, shrinkage losses account for approximately 45% of the total per head cost in rail shipment on important market routes of Nigeria. Doutressoule (1950) reports 25% per head live weight losses in rail shipment from Mali to Senegal.

As in the case of truck transport shrinkage, gastrointestinal parasites may cause the greatest shrinkage attributable to non-infectious diseases.

BRUISING, CRIPPLING AND DEATH

Although shrinkage is a very important variable in losses related to livestock transportation, it is not unique. Many other kinds of losses occur in transporting livestock. The most important among them are: bruising, crippling and death. These losses result from a great variety of causes. However, they are largely influenced by factors such as the type of transportation used and, to a lesser extent, by non-infectious diseases. Knowledge of the nature of these losses and their related causes can help establish practices for reducing the extent of such losses.

1. Bruising

Livestock, during the process of marketing, are often injured by bruising. Bruising may result from accident or from improper handling and may affect different parts of the animal. Livestock may be injured while being loaded onto motor trucks or railroad cars at the local shipping point, while en route to market or slaughterhouse, while being handled at the market, or after delivery is made at the plant. All meat that is damaged from bruising should be condemned as unfit for human food. The bruised part of carcasses may be cut and used for various inedible by-products.

Bruises may exist in a number of forms, but the only types that are usually possible to detect in the live animal are those in the form of cuts or gashes. However, of greater economic importance are those bruises which occur as localized tissue damage or larger areas (fire bruises) and as deep-tissue bruises. These constitute the major portion of bruises and cannot be detected until the carcasses are broken down into the wholesale or retail cuts. Some of the worst bruises occur when animals go down in cars or trucks and are trampled by other animals.

The causes of bruises are varied and numerous. An important part of all bruises are man-made, resulting from careless use of clubs, canes, or whips. In addition to these man-made factors, there are other major factors which include: hooking by horned animals, overcrowding in cars and trucks, and underloading cars and trucks without precautions to prevent excessive jostling.

Based on these causes, one would deduce that, in Africa, bruising may be considerable in truck or rail car transported livestock since they are subject to much rough handling throughout the marketing process. This is due, in part, to failure to appreciate the effect on the carcasses and hides since damage from bruising usually cannot be detected in a live animal, and also because it does not appear as an item of cost in the account of sales. Thus, there is no reason for traders to adopt practices that would reduce or eliminate such losses if they are not associated with other losses such as shrinkage. Bruise losses, however, may have a great effect on the total meat supply and on butchers' margins.

2. Crippling

In addition to extensive bruise losses, many livestock arrive at the market or plant crippled from injuries received in loading or in transit. Livestock that are crippled en route to the plant or to the market are sold at a lower price.

The term crippled is sometimes very confusing. Indeed it has a very broad definition. Usually an animal that arrives in such condition that it cannot walk into the pens unassisted is recorded as crippled. According to Doutressoule (1950) about 8% of 50 cattle trekked from Mali to Ghana were reported crippled en route and sold at a lower price. John Staatz (1980) estimates 1% loss for forced sales from the overall percent of investment in exporting 50 head of cattle from Niono (Mali) to Bouak (Côte d'Ivoire), and 1.6% loss for forced sales of total costs of transporting 50 head of cattle from Tingrela (Côte d'Ivoire) to Bouak. Larry Herman (1983) estimates 1.5% of forced sales loss from the total cost per head of trekking cattle within Upper Volta (now Burkina Faso).

In some instances, animals that limp badly and that show evidence of pain are recorded as cripples at the time of unloading, even though they are able to move out of the cars or trucks without assistance. In addition, livestock that are unable to move through the yards with the rest of the lot because of emaciation or exhaustion are frequently recorded as crippled. John Staatz (1980) reports a 4% loss for forced sale costs of 50 head of cattle shipped by truck from Niono (Mali) to Abidjan, a distance of 1100 km. He reports a 1% loss for forced sale costs in a truck shipment of 50 head of cattle from Koutiala (Mali) to Abidjan, a distance of 600 km, and 0.6% loss per head for forced sales in transporting cattle within Côte d'Ivoire from Tingrela to Bouak by truck. Herman (1983) estimates a 2.16% per head loss for forced sales.

The causes of the crippling are mostly injuries received before transportation, i.e. in loading or in transit.

3. Death

Many animals arrive dead at the market or plant. Some die en route, others die after arrival at the market and before they are sold and slaughtered by butchers. Part of these deaths are due to animal diseases before shipment such as trypanosomiasis, gastrointestinal strongylosis, hepatic distomiasis, hunger or fatigue in trekking, and injuries received in loading or in transit in rail and truck shipment. Livestock that die on the way to market, at the market, or at the plant are a total loss to the owner. However, it is rare to encounter such a total loss. Usually animals are sold before they die.

Doutressoule (1950) reports 2% mortality for 50 cattle trekked from Mali to Ghana. Kellogg (1971) reports, in eight surveys in Nigeria, 5% mortality (cost) per head of the total transport cost due, to a great extent, to trypanosomiasis contracted as the cattle walk through the tse-tse fly belt. John Staatz (1980) reports 9% mortality cost of total transport costs for 50 head of cattle shipped by truck from Niono to Abidjan, and 4% mortality cost in a truck shipment of 50 head of cattle from Koutiala through Abidjan. In transporting 50 cattle within Côte d'Ivoire from Tingrela to Bouak by truck, he reports 1.6% cost for mortality. Kellogg (1971) reports, in his Nigerian survey, an average total cost per head of 4.6% due to mortality in trucking. Herman (1978) estimates mortality at 8% of total per head cost in rail shipment from Ouagadougou to Abidjan. Staatz (1979) estimates the cost of mortality at 5% of the total cost per head in rail shipment from Ouagadougou to Abidjan. Kellogg (1971) estimates mortality cost per head at about 2% in rail shipment on important Nigerian railways.

MEAT LOSSES

In addition to shrinkage, bruising, crippling and death occurring during the marketing of livestock, it is also necessary to consider the possible losses in weight and quality. Under good organization, the transportation of meat should involve very small losses in weight. However, where operating conditions are difficult, the risk of deterioration or spoilage as a result of transport delays can be a serious matter. In some cases, however, the reduction in quality may be directly associated with tissue shrinkage since the ratio of the relative weights of meat and bone in a given weight of carcass are unfavourably affected. Also, if an animal has been kept in a state of disease, of nervous tension, and/or not properly fed and watered

for a long time before slaughter, it loses fat and the texture of its carcass is adversely altered. The muscular parts become more watery due to a significant depletion of the equilibrium level of muscle glycogen. This can be caused, among others, by chronic non-infectious diseases or by prolonged shipment.

The quality of a carcass can be seriously damaged if the animal has recently suffered knocks and bruises. This consideration is often neglected because the damage cannot be seen until after the animal has been slaughtered and dressed. Bruised areas then show up as dark, bloody patches in the flesh and must be removed before the meat can be sold. Other factors of meat quality loss are helminth parasites such as cysticercosis in some muscles leading to partial or total rejection of the carcass at meat inspection. Moreover, affected livers due to hepatic distomiasis are also rejected at meat inspection. These rejections add to financial and meat losses.

RECOMMENDATIONS

Except for some measures related to disease control, such as the use of trypanocidal drugs against trypanosomiasis, little precautions are taken by drovers and traders to protect livestock against losses during transit in West Africa.

From the local shipment point to the terminal market or to the slaughterhouse, there are many points along the marketing route where lack of care and poor judgment might increase losses and thus, lower the net return of the cattle traders. One such point is making proper and adequate preparation for shipment.

While careful planning for shipment can contribute much to increase net returns through reducing losses from deaths, shrink, bruises, and crippling, poor and inadequate preconditioning may easily overshadow any advantage gained through a wise selection of the time and the place to market the livestock. Therefore, much should be done to control excessive shrinkage and to have cattle yielding the maximum weight possible.

Among the major reasons to consider in reducing unfavourable conditions of shipment, loading facilities, handling, loading and unloading conditions, distance and time of transit, weather, amount of fill, condition of vehicle, road conditions, disease control and/or treatment are essential.

If livestock are to be loaded, appropriate holding pens and loading chutes are necessary so that the livestock may be easily and quietly walked into the trucks or rail cars. With the use of chutes, loading and unloading are not only more expeditious but there are fewer bruises.

Before loading, cars and trucks should be carefully inspected for cracks and broken boards and for poor bedding or footing. In general, too much straw is not recommended when it is very hot since straw bedding generates heat. When straw is used it is preferable to lay it over a layer of sand to ensure better footing and thus prevent frequent slipping and falling. Livestock that go down in the truck or car in transit are trampled, resulting in extensive bruises and sometimes death. When sand is used with or without straw, it should be free of stones to prevent slipping. Moreover, a stone imbedded in a hoof may cause

crippling and will be reflected in a lower value for the animal. One or two inches of clean sand is sufficient. Good footing in a truck or car means a lot in livestock comfort.

Slow and careful handling at all times is very important for livestock to reach their destination in good condition. They should be moved slowly and quietly to avoid bumping and jostling against gate posts and overcrowding in the loading chute. Animals are generally shy about going into strange places such as trucks and rail cars, and even pens, and they should not be rushed into the new environment if undue nervousness, with an increased amount of shrinkage, is to be avoided.

Adequate measures should be taken to protect livestock against diseases and, in particular, trypanosomiasis, by use of trypanocidal drugs if they walk throughout tse-tse infested areas of forest. Moreover, treatment should also be carried out against gastrointestinal parasites with anthelmintics with the specific purpose of eliminating parasite disease risks for animals from infested areas. Considerable technology is available for control of all, or most, of the non-infectious diseases discussed in this paper. The technology is generally effective except in cases of inadequate transport management systems.

Where the market for the carcass meat demands quality, attention must be given to protecting livestock from stress before slaughter. In addition to measures already mentioned to control diseases, to avoid exciting, frightening or exhausting the livestock at any stage of the marketing process, whatever the method of transport used, it is important for livestock to be rested at least 24 hours before slaughter. During this period, livestock may be watered but not fed. Otherwise, if an animal is slaughtered while still under stress, the bleeding of the carcass may be impaired and the meat tissue could be contaminated by bacteria passing the gut wall and the blood and lymph systems. This may affect the colour and texture, and thus the quality of the meat, and will reduce the time it can be kept before it begins to putrefy. This point is very important for the conservation of meat under tropical conditions.

A particular recommendation should be directed toward providing incentives or education and awareness to people who are involved in the business, particularly drovers and conveyers, because most losses reflect human attributes, i.e. short tempers, impatience, hurry, carelessness, and unfortunate callousness. However, most losses occur either because people do not realize how much damage is done, because they have not learned that it is very much within their power to reduce these losses or they do not have incentive to treat the animals better. Thus, it may pay off to make people in the business more aware of the costs associated with livestock losses and to give rewards such as extra salary, permanent jobs, gifts, etc. to conscientious workers in their handling of animals. It is a matter of good business and future job security to be able to deliver livestock at a minimum shrink, free of cripples, with no deaths, and with no bruises showing up at the market or inside the plant.

In addition to the above recommendations, government policies are also required in order to achieve the objective of minimum losses and low cost distribution in the transit of market livestock. These policies include:

- provision of improved infrastructure and central marketing facilities (roads, railroads, slaughterhouses, feed and water facilities, public livestock markets);

- provision of adequate institutions (credit institutions, producer cooperatives, trucking and rail industries);
- provision of adequate regulations and controls in marketing (animal health, handling in transit and consumer protection); and
- provision of effective research, training and extension services.

RESEARCH NEEDS

An evaluation of various losses occurring during the marketing of livestock is not yet possible since the results of the studies made in this field are very limited.

So far, because of the difficulty to isolate the impact of each factor of losses, the research needs basically should be oriented to finding the magnitude of losses such as death, shrinkage, crippling, bruises attributable to non-infectious diseases, transport management, and to judge how these losses may be affected by alternative methods of transport and other factors.

The relationship between live weight shrinkage and real tissue loss is also very important in discovering the amount of edible meat loss.

Estimations of economic loss occasioned by bruises and other carcass damage during rail and truck shipment, and more accurate measurement of the effects of trypanosomiasis and non-infectious diseases in trekking are needed.

The above information will have an important effect on the better understanding of losses occurring during livestock marketing in West Africa, particularly in determining the best strategies in marketing systems.

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FOOD LOSSES DUE TO DISEASES RELATED TO TRANSPORTATION/TREKKING AND PROGRAMME FOR THEIR REDUCTION

by

P.G. Chambers^{1/}

SUMMARY

Food animals provide the human population with meat, which is both a nutritious food and a valuable commodity. FAO statistics indicate that in 1989, developing countries produced 54 million metric tons of meat derived from the slaughter of some 906 million animals.

Food animals need to be transported for various reasons, including to markets, away from drought areas, and for slaughter. However, transportation and related activities have deleterious effects on these animals which can result in considerable loss of food.

In Zimbabwe, food animals are transported chiefly by road motor vehicles, with a small proportion by rail wagon and on the hoof. Some 900,000 animals are transported by road motor vehicle for slaughter and, in 1990, 451 cattle, pigs and sheep/goats were lost due to causes related to this transportation, representing 33 tons of meat. In addition, some 93 tons of meat were lost due to bruising. This loss represents 0.07% of the total annual meat production from these species. If this figure could be extrapolated to developing countries, food losses due to the effects of transportation on animals destined for slaughter alone would be in the region of 14.7 million metric tons.

The effects of transportation on food animals, resulting in losses of meat, have been shown to be:

physical injury (e.g. bruising, fracture)	poisoning	cardiac failure
exhaustion	theft	sunburn
stress	predation	fighting
septicaemia	accidents	ketosis
dehydration	bloat	Salmonellosis
	heat stroke	transit tetany

Several major factors play a role in the effects of transportation on food losses in animals. These include:

Role of Management

- pre-mixing of animals before transport
- feeding and watering prior to transport

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facilities for loading/unloading
farm management

Role of Animals

mixing of horned and polled animals
mixing of animals of different sexes
temperament of animals
mixing of different species
unfit animals

Role of Vehicle

suitability of vehicles
floor space
packing of animals

Role of Journey

length of journey
time of day
exposure to elements
manner of driving

Role of Trekking

length of journey
necessity for planning
risks involved

In order to develop an appropriate national or district programme for reduction of the potentially considerable losses of food due to transport/trekking, the following data should be systematically gathered and evaluated:

- main methods of transportation used
- methods of transport used for different species of animals
- numbers of different species transported
- suitability and defects of vehicles currently used
- causes of death and injury in food animals due to transportation.

This information can be collected at markets and slaughter houses and will identify the main types of losses caused, the numbers of animals affected, quantities of food losses and important reasons for their losses.

An educational programme for authorities can be developed, underlining the significance of food losses due to transport and advocating corrective measures to be taken.

INTRODUCTION

The need to transport food animals occurs essentially in commercial agriculture, as well as, to a lesser extent, in the subsistence sector. These animals need to be moved for various reasons, and within developing countries the chief methods of transport are usually by road motor vehicles, rail wagons and on hoof. Food animals provide the human population of the world with much needed meat, which is a highly nutritious food and a valuable commodity. FAO statistics indicate that world meat production from cattle, pigs and sheep/goats in 1989 was in the region of 132 million metric tons produced from the slaughter of some 1 766 million of these animals. In developing countries, in the same year, production of meat from the slaughter of 906 million cattle, pigs and sheep/goats was some 54 million tons or 41% of the world's total. Transportation and the related activities do have deleterious effects on these animals and could result in a significant loss of this production.

Zimbabwe is classified as a developing country although commercial agriculture is relatively sophisticated. The commercial production of meat (food) from food animals in 1990 was 139 thousand tons obtained from the slaughter of 964,000 cattle, pigs and sheep/goats. Food animals in this country are mainly transported for slaughter, although cattle are moved for other reasons, such as: to and from auction sales, to feedlots and relocation during drought years. A small proportion of subsistence cattle and sheep/goats owned by the rural population may be moved on foot to better grazing.

During 1990, 451 cattle, sheep/goats and pig carcasses were lost due to the effects of transportation to slaughter or during transit. These animals represent 33 tons of meat. In addition to carcass losses, partial loss due to bruising was an insidious, yet highly significant cause. Approximately 18% of cattle transported by road motor vehicle in Zimbabwe are bruised, resulting in an average of 0.86 kg of bruise tissue loss per animal. This represents some 93 tons of food lost. If the Zimbabwe scenario could be regarded as a relatively minimal-loss one and if this loss could be extrapolated to food animal slaughter in developing countries, 14.7 million tons of bruising would be lost from the slaughter of 95 094 000 cattle (FAO Yearbook, 1989). This paper highlights the deleterious effects that transport can have on animals, particularly those on cattle, pigs and sheep/goats being transported for slaughter, and suggests how these effects may be reduced in order to reduce food losses.

EFFECTS OF TRANSPORTATION ON FOOD ANIMALS

Methods of Transport

Food animals may be transported for a number of reasons, including marketing, slaughter, re-stocking, away from drought areas, or to better grazing and change of ownership. In developing countries it is suggested that transportation is effected generally by means of road motor vehicles (RMV) and to a lesser extent by rail wagon (RW) and on the hoof (trekking).

In Zimbabwe the RMV is the method of choice, mainly because there is a good network of primary and secondary roads. In 1990, food animals in this country were transported for slaughter by the following means:

<u>Cattle</u>	Road Motor Vehicle	97.4%	comm. haulers - 96%
	Rail Wagons	0.1%	
	Hoof	2.5%	
<u>Pigs</u>	RMV	98.0%	private/owner - 80%
	RW	2.0%	
<u>Sheep/Goats</u>			
	RMV	99.0%	

The vast majority of cattle and other food animals transported for various other reasons are also transported by RMV.

Diseases (Conditions) Caused by Transportation Resulting in Food Loss

Detailed records kept in Zimbabwe over the last 20 years of reasons for losses of food animals being transported (mainly for slaughter), together with information from Kenya, Botswana, South Africa and Australia, show that losses attributable to deleterious effects of transportation and related activities may occur for the following reasons:

Cattle

- physical injury
 - fractures
 - suffocation
 - trampling
 - bruising
- exhaustion
- dehydration
- stress
 - toxæmia/septicæmia
 - dark, firm dry beef (DFD)
 - bad bleeding
- poisoning
- theft
- bloat
- predation
- accidents

Bruising in cattle is the single most significant deleterious effect that transport has on food animals, and is also the most insidious. For this reason, bruising in cattle will be given separate extra consideration in this paper.

Pigs

- heat stroke
- cardiac failure
- sunburn
- injuries due to fighting
- stress
 - pale, soft exudative pork (PSE)
 - bad bleeding
- joint dislocation

Sheep/Goats

- trampling
- toxæmia
- exhaustion
- bloat

FACTORS THAT PLAY A ROLE IN LOSSES DUE TO TRANSPORTATION

Role of Management

1. **Farm Management.** Management practices such as dipping, weighing and vaccination in the days before loading contributed much to additional injury, particularly bruising.
2. **Pre-mixing of animals.** Experience has shown that animals which are familiar with each other travel much better together than those which are strangers.

Cattle should be mixed in a pen 24 hours before being loaded with plenty of space as the animals are likely to be more aggressive if overcrowded. Wild or victimised animals can be weeded out during this mixing period.

Pigs Fighting amongst pigs that are strangers to each other is notorious, resulting in skin and sub-cutaneous damage. Pigs from different pens should be mixed prior to transport by putting them together in a mixing pen with deep litter or smeared with soils or excreta from the same pen. In hot weather the pigs should be held in a cool place before loading.

Sheep/Goats Experience has shown that pre-mixing of these animals is of little benefit.

3. **Feeding and Watering.**

Cattle should be allowed some food out of racks and water *ad lib* up to the time they travel. This, together with pre-travel rest, ensures that the animals settle better during the journey.

Pigs It is most important that pigs should not be fed during the 12 hours prior to the journey. It is a fallacy that feeding prior to transportation increases market mass and reduces shrinkage. Excessive pressure from an overfull stomach, often together with some distension due to fermentation gas, leads to pressure on the diaphragm and organs of the thoracic cavity, causing circulatory congestion, respiratory inhibition and cardiac failure. In Zimbabwe, this has in the past been the single most common cause of death in pigs transported by rural farmers. Hosing or washing down of pigs before loading makes them more contented and reduces fighting.

Sheep/Goats Action along similar lines as for cattle is necessary.

4. **Loading/Unloading Facilities.**

Cattle Quiet and orderly loading ensures better behaviour during transit. Noise and the use of sticks for driving should be avoided as these cause bruising. Rolled plastic or paper bags, or flat canvas straps, are useful. More amiable animals should be loaded first and last, with fractious animals in the middle. Calves should be loaded manually.

Pigs Quiet, orderly loading is essential. The electric prodder should not be used under any circumstances as pigs are easily frightened.

Sheep/Goats These animals should also be loaded in a quiet, orderly fashion. Often when one animal has been coaxed into the vehicle the others will follow. Soft canvas straps or folded bags should be used for driving.

All animals should be unloaded at their destination by means of either a ramp or platform. The ramp should have cross slats or steps to avoid slipping and consequent injury. The platform should be flush with the floor level of the vehicle and close to the vehicle to prevent animals from falling through.

Role of the Animals

1. **Mixing of polled and horned animals** Workers have shown that bruising and injury en route is significantly increased by mixing horned and polled cattle, or loading horned only cattle, as opposed to polled only cattle.
2. **Mixing of Cows, Oxen and Bulls** Separating the sexes reduces injury, bruising and fighting. In addition, Kenya authorities have shown that exotic breeds of cattle seem more susceptible to bruising than indigenous. Bulls should never be carried in the same vehicles as other stock, unless separated by a strong partition.
3. **Temperament** Statistics collated in Zimbabwe show that the amount of bruising in cattle increases significantly when animals of docile and aggressive temperament are mixed in the same vehicles.
4. **Mixing of Different Species** Sheep, goats and calves under six months can be mixed. Individual animals can be transported in a loose sack tied at the neck. Feet should not be tied and animals should be turned every 30 minutes or so. Failure to observe these rules results in suffocation and bloat. Pigs should not travel mixed with other species unless separated by a partition.
5. **Unfit Animals** Animals that are injured, diseased, emaciated or heavily pregnant should not be moved as they may die en route. Unfit animals such as heavy, pen-fed animals not used to exercise should not move far either by vehicle or on hoof as they usually cannot stand up to the rigours of transport and are more predisposed to injury.

Role of Vehicles

The suitability of transport vehicles is a major factor in the cause of losses due to transport. Road motor vehicles and rail wagons are used internationally for transporting food animals but their suitability is critical.

Road Motor Vehicle (RMV)

1. **Cattle** Cattle are often transported in RMV which are used primarily for other purposes. These vehicles must be acceptable for animal transport, mainly by fitting them with removable structures which will increase the height of the sides to prevent

the animals from jumping out. There should be no gaps through which a leg can protrude and be broken. Floors should be made non-slip by means of a grid (lattice work), which can be removable if necessary, to prevent animals from slipping and resulting in bruising, fractures and trampling. Interior padding of vehicles at hip height with old motor tyres helps prevent injury and there should be no sharp protuberances. Unless animals are exposed for many hours to the hot sun, a roof is not required. Researchers have shown that bedding can reduce bruising by 50%. Vehicles should never be totally enclosed.

2. **Pigs** Adequate ventilation of RMV transport is extremely important as high air temperatures and humidity increase the aggressiveness amongst pigs during travel. Vehicles with steel tube frameworks covered in tarpaulin for a roof are satisfactory where shelter from the elements is necessary. In hot weather the flaps can regulate ventilation. Vehicles with no roofs are satisfactory where the ambient temperatures are mild or where journeys are short and made during the cool of the day.
3. **Sheep/Goats** These animals travel well under the same conditions as pigs.

Note: Small stock can be carried in double decker vehicles provided that the space between the levels is not less than 1.3 m in the case of pigs and 0.8 m in the case of sheep. Exhaust emissions should not interfere with respiration. The partitioning of a vehicle into sections will considerably reduce injury due to jostling and lurching. RMVs should be fitted with a portable ramp, fitted with cross-slats, in case of breakdowns or accidents occurring where animals have to be offloaded.

Rail Wagons (RW)

These vehicles are suitable for transport provided certain requisites are provided.

1. **Cattle** Cross-slatting of the floors is necessary to prevent slipping, and wood gives better footing than metal. Smooth wood or line-metal sides are essential to prevent bruising. Side-entry doors that are too narrow (less than 1.5 m) cause considerable injury and bruising. There should be a drainage opening 5 cm. high along the length of the RW and a spring coupling on wagons is recommended to cushion truck movement.
2. **Pigs** RW for pig transportation requires free flow of air at floor level. The floor should also be made non-slip with sand, sawdust or straw. Partitioning of the RW every 2.5 m will considerably reduce bruising and fight wounds.
3. **Sheep/Goats** The same general recommendations apply to these animals.

Floor Space

The table below gives recommended floor space for transporting different species:

CLASS OF STOCK	FLOOR AREA/ HEAD - sq.m.
Mature cattle	1.0 - 2.4
Small calves	0.3
Pigs - up to 55 kg.	0.3
- 55 - 70 kg.	0.4
- sow and boar	0.8
Sheep/Goats	0.4

Packing

The guiding principle should be that animals should be packed in transport vehicles reasonably compactly to offer support for each other. In the case of cattle, animals packed too loosely will fall down easily and injure themselves. If they are packed too tightly, once they go down they are unable to stand again and become trampled or suffocate. Cattle tend to stand cross-wise to the length of the vehicle and at right angles to the direction of travel.

Approximately 66 cm. of vehicle length is needed for oxen and 57 cm. for cows. Where large numbers of smalls are carried, the use of partitions is recommended.

Role of the Journey

1. Cattle During the first 20 hours of RMV travel cattle stand and show little evidence of fatigue. After this, the animals tend to lie down, risking bruising. After 30 hours they start to become exhausted. The maximum period for the transport of cattle should be 36 hours. If the journey is longer the cattle should be offloaded every 24 hours after the start of the journey for feeding and water. The driver of the vehicle should exert the utmost care - erratic jerky driving of the RMV, or weaving, etc. lead to much injury. In the case of RW shunting, particularly "fly" shunting causes damage. Road vehicles should be provided with an attendant so that the vehicle can be stopped if an animal goes down.
2. Pigs With pigs, restlessness, jostling and fighting are most pronounced during the first 30 minutes of travel. This is aggravated if the pigs are hot and the vehicles stationary. Fighting ceases when the vehicle moves off but recommences when the vehicle stops. Journeys with pigs should be as direct as possible, with a minimum of stopping. Fighting also increases between pigs that are strangers and where the humidity and temperature increase. In hot climates pigs should be transported in the early morning, in the cooler afternoon, or late night, as pigs are highly susceptible to heat stroke and sunburn. In addition, mortality and injury increases with increasing length of journey.
3. Sheep/Goats Statistics show that sheep and goats generally suffer little from transportation provided conditions are generally conducive to comfort.

TREKKING (Movement on Hoof)

Transporting animals on the hoof is really appropriate only for cattle and sheep/goats. The system is, however, an unsatisfactory one as there are many risks involved in driving animals, particularly over long distances. These include exhaustion, loss of condition, footsoreness, exposure, accidents, theft, predation, death from poisonous plants and bruising due to beating with sticks. However the method is still used to get animals to the nearest RMV or RW loading point, stock sale, slaughter facility, or to new grazing.

When animals are moved on the hoof over some distance, the journey should be well planned beforehand. The maximum distance cattle or sheep/goats should be driven daily depends on a number of factors including weather, condition of the animal, its age, etc. and the distance given in the Table below should not be exceeded:

Species	One-day Journey	More than one day	
		1st day	Subsequent days
Cattle	30 km.	24 km.	16 km.
Sheep/Goats	24 km.	24 km.	16 km.

The route should be planned giving special attention to opportunities for grazing or feeding, watering, safety of route from predators, resting, and holding overnight. Animals should be moved in the cooler morning or afternoons, and rested in the heat of the day. The animals should be driven for two shifts of four hours each. When animals are walked to a rail head or loading point they should arrive at least six hours before departure and given rest, feed and water before being loaded. There should be sufficient drovers to carry red flags in front and behind to warn drivers of vehicles and to look for dangers on the way such as hidden holes or dongas that the animals might fall into. If the animals are wild, a few tame ones should be used to lead them.

BRUISING

Bruising of animals in transit is a highly insidious form of injury and the single, most significant, cause of food loss from animals being transported, particularly with regard to cattle.

A bruise can be defined as the rupture of blood vessels in the tissue, chiefly muscle and sub-cutaneous, due to physical trauma with the subsequent escape of free blood into the tissue and tissue damage. Bruised tissue may be unfit or undesirable to eat for various reasons and is condemned at meat inspection, resulting in loss of food.

Food loss due to bruising is of most significance in slaughter animals, particularly cattle, and is due to whole or partial carcass condemnation and trimming of bruised tissue.

In addition, there may be considerable loss of value of the carcase, especially if it is downgraded.

In Zimbabwe, the mass of tissue lost due to bruising of cattle transported for slaughter is 75% of the loss of meat due to all effects of transport. Approximately 18% of cattle transported by RMV are bruised, ranging up to 70% in some badly affected mobs. Similar bruising incidence have been found in Botswana, South Africa and Kenya. Between 0.8 and 1.5 kg of bruised tissue is removed from affected carcasses. The hip was bruised in 48% of cases and the pin bones in 42% and over the shoulder in 31%. In Kenya, bruising occurs over the barrel (chest) in some 26% of cases probably because the animals are in poorer condition and the rib cage is most vulnerable.

It has been shown that there are many factors involved in the causes of bruising during transport and related activities. Most of these have been indicated in this paper, and findings all over the world are similar. Any programme for the reduction of food losses in animals in transit should aim at reducing bruising as a priority.

PROGRAMME FOR THE REDUCTION OF FOOD LOSSES DUE TO DISEASES CAUSED BY TRANSPORTATION

Any programme for the reduction of food losses due to transportation will depend on identifying priority areas for action and the application of appropriate methods of correction.

A substantial data base of information of the current national or district situation must be obtained on which to base informed corrective action. It will be necessary, therefore, in the first instance to:

1. Ascertain
 - main methods of animal transport in current use;
 - different methods of transport used for different species;
 - numbers of different food animals transported by these methods;
2. Carry out a survey of the different types of transport vehicles used in order to assess their suitability or otherwise for transporting food animals;
3. Collect and collate data regarding:
 - cause of death or injury in food animals during transit and related activities;
 - reasons for condemnation of animals and carcasses at slaughterhouses in order to identify those attributable to transport.

This information should be collected systematically from appropriate personnel such as veterinarians and animal health workers situated at various destinations to which food animals are delivered, such as sale pens, markets and slaughterhouses.

With this information an appropriate programme for reduction can be formulated. The programme would consist essentially of educating personnel connected to all aspects of animal transport.

EDUCATION PROGRAMME

All sectors involved in food animal transport, including animal owners and handlers, farmers, transport operators, slaughterhouse managers and workers, etc. must be educated with regard to the importance of food losses and the causes, as well as the measures that can be taken to reduce these losses. This information should be based on the findings and recommendations in this document. Information dissemination should be by means of seminars, film, printed hand-outs, and other methods appropriate to developing countries.

Where possible, a system of incentives or penalties would be introduced such as bonus for hornless cattle or penalty for damaged hides due to transport injury.

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FOOD LOSSES DUE TO DISEASED/CONTAMINATED ANIMAL PRODUCTS AND PROGRAMME FOR THEIR REDUCTION

by

K. Gerigk^{1/}

1. CAUSES OF FOOD LOSSES

1.1 Losses connected with living animals

1.1.1 Non-infectious diseases

(i.e. parasitic infestation, trace element deficiency, diseases caused by contamination of the environment, congenital diseases)

- lead to
- eradication of flocks,
 - condemnation of slaughtered animals or parts of them,
 - products (fish, eggs, milk, honey) being unfit for human consumption,
 - quality degradation,
 - decrease of yield.

1.1.2 Disorders due to mistakes in feeding and hatching

(i.e. accumulation of residues and/or contaminants)

- intoxications,
- systemic diseases (enteritis, hepatitis),
- emaciation,
- bruises and injuries,
- abscesses,
- abnormal odours

lead to (see No. 1.1.1)

1.2 Losses due to the environment

Contamination of the environment (soil, water, air) with toxic chemicals or radioactive elements

leads to prohibition of use of products for human consumption, and prohibition of slaughter of animals originating from contaminated areas.

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1.3 Losses connected with slaughter of animals

1.3.1 Transportation of slaughter animals

- overloading,
- unsuitable facilities,
- long-distance transport,
- extreme climates,
- maltreatment or other disregard of animal welfare,
- pollution

- leads to
- quality degradation (injuries, fractures, incomplete bleeding, pale, soft exudative pork syndrome
 - death of animals.

1.3.2 Technical faults

- unsuitable equipment,
- inadequately adjusted machinery (scalding tank, plucking machines, eviscerators, pinchchillers)

- lead to
- ruptures,
 - damage,
 - pollution,
 - microbial contamination,
 - spoilage.

1.3.3 Hygienic faults

- (i.e. lack in general sanitation)
- mistakes in skinning, in evisceration,
 - in discrimination between dirty and clean areas

- lead to
- pollution,
 - microbial contamination,
 - spoilage.

1.4 Technical and hygienic faults in production and transportation of other food (milk, eggs, fish, seafood, honey)

- unsuitable equipment,
- lack in general sanitation (in the farm, on trawlers, in transport vehicles, tanks and vessels),
- lack of refrigeration,
- duration of loading, unloading and transportation

- lead to
- damage,
 - pollution,
 - microbial contamination,
 - spoilage.

1.5 Technical and hygienic faults in processing of food

- imperfect heating (canned or sealed products, milk),
- imperfect processing (drying, evacuation, acidifying, smoking, curing) in dairy, meat- or fish-processing plant

- lead to
- damage (dishing, souring),
 - pollution,
 - microbial contamination,
 - spoilage.

1.6 Faults in storage of food

- excessive humidity,
- lack of refrigeration,
- duration of storage,
- imperfect seal of package

- lead to
- microbial growth, especially mould,
 - quality degradation,
 - freeze burn,
 - spoilage.

1.7 Logistic problems

- lack of infrastructure for distribution and transport of food,
- lack of concepts

- lead to
- prolonged distribution,
 - deterioration.

1.8 Deficiency of surveillance

- lack of veterinary services,
- lack of investigation centres,
- unclear competences,
- lack of engagement (low profit, bad working conditions).

1.9 Deficiency of self-control systems for producers

- Hazard Analysis Critical Control Point (HACCP),
- quality standards,
- purchaser's requirements.

1.10 Lack of scientific basis for

- shelf-life guarantees,
- technical and hygienic requirements in producing and processing, transportation and storage.

1.11 Consumers' deficiency of information

2. PROGRAMME FOR THE REDUCTION OF FOOD LOSSES

2.1 Education in

- scientific based requirements,
- marketing,
- management,
- administration.

2.2 Practical implementation of acquired knowledge

2.3 Legislation and recommendations for

- trade with feedstuffs,
- trade with drugs,
- trade with food,
- meat inspection and meat hygiene,
- disposal of waste materials,
- environmental affairs.

2.4 Improvement of infrastructure

- construction and renovation of plants,
- improvement of traffic conditions,
- improvement of marketing systems,
- instalment of quality control programmes, for production, for surveillance.

2.5 Improvement of environmental conditions by alternative concepts

- reduction in use of chemicals,
- use of alternative energy resources,
- implementation of protected areas for pumping of potable water,
- disposal of wastes and effluents.

2.6 Implementation of special services

- production and use of disinfectants and pesticides,
- construction of plants,
- laboratories for quality control and investigation centres.

2.7 Production and handling of foods in compliance with Codex Alimentarius and other standards

2.8 Monitoring programmes

2.9 Decontamination of foods by

- acids,
- radiation,
- ozonization,
- chlorination,

- heating,
- drying including smoking.

2.10 Consumer information and implementation of consumer organizations

ANIMAL HYGIENE MEASURES FOR PREVENTING FOOD LOSSES DUE TO MULTIFACTORIAL DISEASES

by

Ingvar Ekesbo^{1/}

SUMMARY

In this paper an attempt is made to identify priorities, to give concrete recommendations of methodology and to recommend actions to be taken in order to reduce food losses from non-infectious diseases in developing countries by using experiences from trials and errors in industrialized countries. Problem areas are defined for which animal hygiene and other measures are proposed for reduction of food losses.

The following problem areas are defined:

- The change in disease pattern which has been a result of changes in animal husbandry.
- Disease evoking factors in housing and management.
- Animal transportation as a disease factor.
- The herdsman.
- Connections between increased production traits and animal health and disease.
- Genetic manipulation and animal health.

The following other measures for preventing food losses are proposed:

- Improvement of biological, especially ethological, knowledge.
- Improved research and veterinary education regarding relationship between animal husbandry methods and animal health including cost-benefit-analyses of preventive measures.
- Advice to farmers, and their technicians, on design of farm premises and change of husbandry methods given by specially educated veterinarians.

The following other measures for preventing food losses are proposed:

- Genetic measures for avoiding disease and improving animal health.
- Legislative measures in order to ensure:
 - genetic manipulation does not cause losses
 - preserving of existing farm animal genetic material
 - control of substances intended for increase of production traits
 - animal welfare

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INTRODUCTION

In this paper an attempt is made to identify priorities, to give concrete recommendations of methodology and to recommend actions to be taken in order to reduce food losses from non-infectious diseases in developing countries by using experiences from trials and errors in industrialized countries. Problem areas are defined for which animal hygiene and other measures are proposed for reduction of food losses.

In order to understand the situation in any country, industrialized or not, it is necessary to have a perspective of the current farm animal health and husbandry. A total review of the known common history of man and farm animals reveals that the period since the 1950's seems unparalleled as far as drastic changes are concerned. The difference between this short and dynamic period and the earlier long development lies, however, not only in the intensive and successful breeding and feeding for increased production and in the introduction of many innovations in farm animal environment and management methods during a short period. There is also the fact that these changes have affected practically every farm in most industrialized countries and have also had more and more influences on animal husbandry in the developing countries. The era in which we live is thus unique in this respect.

At the same time as these changes have occurred, there has arisen, as we all know, a changed disease panorama in farm animals with a considerable increase of new animal health problems. New types of animal welfare problems have also appeared.

The changed disease panorama is characterised by two main elements. One is a reduction of the purely infectious and contagious diseases as a result of successful veterinary research, organisation and practice. The second is an increase of diseases caused primarily by environmental or managerial factors combined or not with secondary affecting microorganisms.

Animal hygiene is usually defined as "The science regarding the influence on animal health and disease by factors in the animal environment including management combined or not with secondary affecting microorganisms and measures taken with such factors in order to promote health and to prevent disease". Examples of such environmental or managerial factors are housing, pasture, waste and feed handling methods, climate, noise, light, dust, straw, animal handling, animal transportation, etc. It also comprises the influence on the environment by animal husbandry. Thus, it is one of the most important sectors of preventive veterinary medicine and the discipline therefore has a great responsibility in our time, not least in the developing countries.

Current animal husbandry in several countries is questioned, not only as regards efficiency in structure, ownership, production, animal health and economy, but also ethically. It is clear that there is a strong link between animal health and animal welfare and that ethics have an important role in modern animal husbandry. Experience shows that in every industrialized country the veterinarians, the authorities and the farmers, but also the public, ask for scientific facts and information necessary for decisions of great significance for the future production of food originating from farm animals in order to keep the more and more high producing animals healthy, to promote their well-being and to avoid losses. Such decisions are often complicated and far-reaching and comprise many aspects for the country

and its people, involving ethical, economical, demographic, environmental protection and other considerations. It is of utmost importance that experiences in this field from the industrialized countries will become utilized in the developing countries.

IDENTIFICATION OF PROBLEM AREAS

The changed disease panorama - Background, pattern and diagnostic problems

A global analysis of the changes of the environment, including management, since the 1950's, indicates a strong trend to replace the biology-based strategy of traditional farmers with a technology-based production strategy. In the former, the technical aids like the saddle, the harness, the yoke, the stanchion or the pen were developed over many thousands of years of trials and errors and were adapted to species-specific biological requirements. In the latter, the animals are forced to adapt to the technical constraints of the different systems offered to the farmers.

The increase of environmentally evoked diseases during the latest decades is mainly an unforeseen result of the change-over from the primarily biology-based strategy in traditional animal husbandry into a primarily technique-based strategy in many modern animal production systems. Farm animal environments and management methods are changed in order to get greater efficiency in animal production without taking into enough consideration the implications for animal health. The new technique has been holding out the prospect of gains through more efficient animal production. However, these gains have turned out to be reduced by food losses mainly due to man made diseases in industrialized as well as in developing countries.

Examples of man made diseases, the increase of which have caused food losses in industrialized countries are: mastitis in cows; mastitis-metritis-agalactia syndrome (MMA) in sows; salpingitis in egg laying hens; hoof or claw disease in cattle, swine, and poultry; respiratory diseases particularly in the intensive beef producing herds or in pig herds; diseases in the digestive system such as diarrhoea in calves and piglets, salmonellosis in poultry and in cattle; so called production diseases e.g. parturient paresis and ketosis in dairy cows; traumatic injuries or other animal health disturbances induced during animal transportation.

To conclude, the applications of new animal environments and management methods for farm animals too often have caused serious food losses through animal health disorders, which also have implied animal welfare problems. In other words, gains offered by technology may often be reduced by food losses through animal diseases caused by unsatisfactory or poor adaptation of technology to biological necessities. It is important that the developing countries, by preventive measures, try to avoid such losses.

One great problem in connection with the food losses due to non-infectious disease problems is the complex disease etiology. Most primarily non-infectious diseases, e.g. hoof diseases, udder diseases, respiratory or alimentary diseases, are multifactorial. One disease in a species, e.g. accumulation of clinical mastitis cases in a dairy herd, may be primarily caused on one occasion by traumatic teat injuries, on another occasion by bad hygienic conditions of the drinking water. On the other hand one specific managerial or

environmental factor, e.g. bad feed hygiene, may on one occasion result in one disease, e.g. mastitis in sows, on another occasion result in another disease, e.g. diarrhoea. Effective prevention of food losses due to non-infectious diseases therefore necessitates a thorough knowledge of the qualitative and quantitative impact by factors in the animal environment, including management, on the health of different farm animal species and of the qualitative and quantitative relationship between the etiological factor and the resulting disease or disease sign.

Disease evoking factors in housing and management

In most industrialized countries severe infectious diseases like foot and mouth disease, tuberculosis and brucellosis are under control or have been eradicated, and diseases caused by lack of feed or underfeeding are observed very seldom or do not exist any longer. There is, however, a considerable increase of new animal health problems, mostly multifactorial man made diseases. When studying their etiology practically one will always find environmental factors, including management, alone or in combination with infectious agents. When saying this it is necessary to bear in mind that the modern high yielding or fast growing phenotype of farm animals as a rule have higher requirements with regard to the environment, including management, than the phenotypes which were used forty years ago.

It is demonstrated that the incidence of trampled teats and subsequently mastitis in dairy cows are increased by several environmental or managerial factors, e.g. zero-grazing (Dohoo and Martin, 1984; Bendixen *et al.* 1986; Bendixen *et al.* 1988a, 1988b), limited use or lack of bedding (Ekesbo, 1966; Oltenacu *et al.* 1991), slatted floors in the lying area (Ekesbo, 1966). More than 40% mastitis is common in high producing herds housed in unsuitable environments (Ekesbo, 1966). A positive correlation is shown between the use of so called electric cow trainers and the increase of mastitis incidence (Bakken, 1981) and there are also indications of negative effects on reproduction (Eyrich *et al.* 1989; Schopper *et al.* 1989). Tail biting in pigs (Lindqvist, 1974; van Putten, 1979) and pecking in hens (Svedberg, 1988) are also demonstrated to be associated with barren environments. Piglets weaned at 3 - 4 weeks and kept in cages or flat deck systems show significantly higher incidence of abnormal behaviour. Such behaviour causes injuries, e.g. tail and earbiting (Algers 1982a; 1982b). Manure gas poisoning is a disease problem associated with herds kept in premises with liquid manure handling (Högsved and Holtenius 1968; Lindqvist, 1974). Traumatic foot injuries in cattle (Ekesbo, 1966), pigs (Bäckström, 1973; Algers 1982b), and poultry (Svedberg 1988) have increased when the animals are kept on unsuitable flooring. Sows kept in stalls and boxes, instead of being loose in pens, show a higher morbidity. This applies also to their offspring (Bäckström, 1973). Hoof disease in tied cows seems to increase when short cut straw or sawdust is used as bedding instead of non-cut common straw (Ekesbo, 1966). In specialized beef herds where the calves are purchased from different herds, the incidence of respiratory diseases is reported to exceed 75% (Miller *et al.*, 1980). Respiratory disorders are a great problem in all herds of fattening pigs, beef calves, and poultry where an all in - all out system is not used. Respiratory disorders also have been reported from pig herds and turkey flocks because of dust problems (Collins and Algers, 1984) created by a combination of too dry climate, ventilation, and unsuitable technical systems for feed distribution. Total area less than 0.7 m²/pig, more than 500 pigs per section, air volumes less than 3 m³/pig are conditions which reportedly contribute to increase morbidity of fattening pigs (Lindqvist, 1974).

Animal transportation as disease factor

Transport of animals, especially animals for slaughter, seems to become of increasing importance as a factor for food losses.

There are a great many investigations demonstrating the effect on animal health by different factors in connection with loading, transport and unloading. Parameters studied are injuries or bruises on the animals, behaviour, blood parameters, changes in muscular histology, e.g. PSE and DFD. Feeding and watering before and under transportation are of importance for preventing losses (e.g. Schütz, 1975; Mickwitz and Wähaus, 1980; Lister, Gregory and Warris, 1981; Nielsen, 1981; MacDonald, 1981). It is possible to reduce losses if the animals are handled carefully (e.g. Bünger, 1974; Steinhardt *et al.*, 1976; Rülcker, 1968; Lannek, 1976; Grandin, 1978; Reuter and Stolle, 1975). The effect of transport distance is studied by Poulanne and Aalto (1980), Schmalfuss and Käsebier (1978), Friend *et al.* (1980), Ramsay (1977), Yeh *et al.* (1978), Malmfors (1982) and it is apparent that the way the transportation is performed is of more importance than the distance, but also that long distance transportation is more detrimental than short distances. The importance of good climatic regulation is demonstrated by Allen (1979).

The herdsman-farm animal bond

Attempts have been made to evaluate the role of the herdsman for animal health and welfare (Seabrook, 1984; Hemsworth, 1987). Such an evaluation faces the same difficulty as when one has to evaluate how different qualities in parents, teachers, etc. affect a child's mental health. However, there should be a consensus agreement between experienced veterinarians, who every day visit many different herds, that the animal health and welfare in the single herd to a large extent depends on the herdsman, and on his ability, not only to manage the herd, but also to establish a positive relationship with his animals. Naturally there is a great difference in the man-animal relationship between on the one side, dairy cow herds, and on the other side, beef, sheep or poultry herds.

When no positive herdsman - animal relationship exists, the herdsman has lost an extraordinarily important stimulating factor, an additional dimension, in his labour. This effect on the herdsman, which to date has not been a subject for thorough scientific studies but which is empirically well known, should not be under-estimated. There are reasons to assume that this effect on the keeper can increase his effectiveness, perhaps positively influence his health condition and in that way increase, not only the pleasure he takes in his work, but also the productivity of his work. It is therefore of importance in order to avoid losses through bad stockmanship that the local good and positive animal husbandry traditions in each developing country are taken care of in parallel with attempts made to increase production efficacy.

Connections between increased production traits and animal health and disease

First a short look will be given to changes in farm animal phenotypes, on the health implications of such changes and on what we can learn from this. When breeds were first developed within the species, man obviously took many factors into consideration, e.g. vitality, temperament, fertility, etc, even if the main objective was milk, meat, wool or

draught animal production. During the last decades very effective selection aiming mostly at increased production has been practised in several industrialized countries. Together with more effective feeding, this, in some such countries, has resulted in an increase of 60 - 70% in dairy cow milk production, an increase of growth rate between 15 and 100% in cattle, swine, and poultry depending on species and breeds, and an increase of more than 80% in egg production per hen per year. In some species and breeds, considerable changes of exterior traits also took place. Experience over the last thirty years shows that surprisingly often the broad biological approach to breeding has been abandoned. Parallel with the changes of the phenotypes, changes in the disease panorama have also occurred. A few examples will be given in order to elucidate the possibilities for the developing countries in their national breeding programmes to avoid mistakes made in some of the genetic programmes for increased productivity in the industrialized countries.

Some diseases, e.g. parturient paresis (Bendixen *et al.*, 1987) and maybe also mastitis in dairy cattle, are positively correlated to the level of milk production. The pecking of the cloaca region of adult chickens and egg laying hens of high producing hybrids has increased considerably and is a great problem in many flocks during the period from 16 to 30 weeks of age (Svedberg, 1988). Parallel to the increase of growth rate of several breeds of pigs, poultry, and cattle, skeleton disorders such as osteochondrosis (Reiland, 1975; Poulos *et al.* 1978), have become more frequent. These disorders have often caused serious clinical syndromes. Changes of phenotype in some breeds, e.g. the Belgian Blue and Charolais beef cattle, resulted in increased incidence of dystocia. More than 50% incidence of caesarean section is reported as a result of breeding for increased muscle mass, especially in the thigh region, of the newborn calf (Menissier and Foulley, 1979).

Genetic manipulation and farm animal health

Some years ago, great publicity was given to experiments in which several copies of the gene for the human growth hormone had been introduced into mouse embryos (Palmiter *et al.*, 1982). This caused later born mice to develop into "giant mice". Successful genetic manipulation of animals kept for farming purposes is feasible and has been performed, e.g. for pig, cattle, sheep and chicken (Rexroad *et al.*, 1989; Bondioli, 1990; Chen *et al.*, 1990). Introduction of genetic material into somatic cells is of consequence only for the animal or animals that carry the manipulated cells. Genetic manipulation of the fertilized egg or early embryo has more far-reaching consequences and also much greater potential with regard to commercial utilization (Berg, 1989).

The introduction of an exogenous gene or gene structures into an early embryo may cause integration into an area of the genome where the foreign DNA may lead to unfortunate consequences (Pinkert, 1987; Rexroad and Pursel, 1988; Pursel *et al.*, 1989). Unjustified integration of exogenous genetic material is apparently not just a theoretical possibility (Berg, 1989). There are apparently demonstrated detrimental effects on the health of transgenic animals (Pinkert, 1987; Rexroad and Pursel, 1988; Pursel *et al.*, 1989, 1990). Altered endocrine profiles, metabolism changes, altered thermoregulation and libido, lowered fertility, increased susceptibility to infections, lameness and arthritis are reported (Pinkert *et al.*, 1990).

Genetic manipulations, however, may offer possibilities to improve animal health and welfare. The chromosomal localisation for more and more hereditary diseases may be mapped out (Lalley *et al.*, 1989). There are examples of enhanced resistance against infection by *Salmonella* strains in mice (Edwards *et al.*, 1989) or leukosis virus in poultry (Salter and Crittenden, 1989) which were obtained by genetic manipulation. Any genetic manipulation aimed at improving the animals' health would seem highly commendable. However, when the desired changes might be obtained by traditional breeding experiments, this procedure should be preferred because it does not carry the risks of uncertainties caused by integrating exogenous genes or gene structures into the genome.

ANIMAL HYGIENE MEASURES FOR PREVENTING FOOD LOSSES DUE TO MULTIFACTORIAL DISEASES

Improvement of biological knowledge - A possible medium-term strategy

The change-over from traditional husbandry with several species to animal production systems with only one species or even one age group on each farm means that the individual farmer's own fund of passively acquired broad biological knowledge is disappearing or has already disappeared. Without such biological knowledge the farmer cannot perceive all the signs of health and disease revealed by the animal's behaviour in different situations. In order to avoid diseases caused by wrong application of husbandry methods the strategy must change primarily from technology-based animal husbandry back to biology-based, where management, housing and breeding are adapted to the animal's need for good health and welfare. This does not mean that technical aids should not be used. It means that they shall be used in the right way. A biology-based strategy requires biological knowledge. In order to fulfil this need for knowledge, three groups of people must receive a thorough education in the biology, and not least ethology, of farm animals than is often available today, namely the farmers, their animal husbandry advisors and the veterinarians.

Several new management methods, e.g. waste and feed handling, imply hygienic risks. Without special hygienic knowledge which very few farmers will have, such risks cannot be foreseen or handled and neither will the necessary measures be taken to prevent animal diseases.

The problem is that the farmer, today and in the future, as long as the trend toward greater specialization on each farm will continue, needs more biological knowledge from outside than he receives at present. This is true also for farmers' advisors. Courses in ethology of farm animals should be given in every agricultural school at all levels. Better ethological knowledge means that the most important factor for animal health, i.e. the man, will be more a good health promoter than a risk factor for diseases in the future animal husbandry. The need for daily care would be given more priority and the risk of substituting it with automatic technical devices or of compensating by drugs (Bogner *et al.*, 1978) will be diminished.

Nowadays the farmer in the most industrialized countries, in his often very difficult situation, needs further dimension of veterinary support and judgement. In modern animal husbandry in industrialized countries, farmers are also increasingly asking for a close and reliable contact between the veterinarians and all types of herds. To an ever-increasing

extent the veterinarian is being asked to visit the herds regularly, not simply to give shots but to enable proper diagnostics and prevention of herd health problems. This requires a comprehensive veterinary knowledge of animal hygiene, i.e. of the animals' biological needs, as well as of the influence of different environmental factors on the health of each species. Without such knowledge an effective combating of the increasing group of man-made diseases is not possible. Such regular contacts between the veterinarian and the herd-owner needs to be built up successively also in the developing countries.

As regards the competence of the veterinarian, a solid undergraduate education in animal hygiene, covering both theoretical and practical clinical aspects, is the base for this necessary knowledge. However, effective and frequent postgraduate education is also necessary. This is a challenge for the veterinary schools, the veterinary associations, and the individual veterinarian. But first of all, it is a challenge for the departments of animal hygiene and for scientists dealing with animal hygiene problems. Professional competence needs qualified research. Cooperation between relevant departments at veterinary schools in industrialized and developing countries should facilitate such research and education in the developing countries.

Farm animal ethology should be a compulsory topic in all veterinary schools. In only a few countries are courses in farm animal ethology included in the core curriculum of veterinary education. High scientific competence and experience in farm animal behaviour is a corner-stone in all clinical diagnostics. Such knowledge is more important for the veterinarian now than ever before because of changes in animal environment and their influence on animal health. It is of great importance in developing countries to understand and utilize good local animal husbandry methods for preventing diseases.

Improved animal hygiene research including cost-benefit analyses of preventive measures - A medium-term strategy

Analyses made justify the conclusion that animal health and welfare can be considerably improved in current and future animal husbandry if more professional scientific research regarding influence on animal health by environmental and management factors is performed.

An important reason for the increased disease problems in modern animal husbandry is the changing economic strategy. In modern animal production the farmers are advised by specialised experts. The risk with this is that the result very often becomes a "sectorial" economic strategy instead of the more holistic view in the traditional agriculture. As the costs for buildings, labour, and feed are easier to estimate than the costs for diseases, the latter are often forgotten in the economic calculations and models.

Therefore, it is necessary to have a thorough scientific investigation carried out regarding the influence of different factors in the animal environment and management on the prevalence of diseases. The results of such research would make it possible for veterinarians and agricultural economists to jointly analyze the cost influence of different diseases and to make cost-benefit analyses of changes in breeding, environment, and management. Thus, the farmer would get a more holistic and realistic view on his animal husbandry activities.

Also here research cooperation between relevant departments at veterinary schools in industrialized countries and in developing countries should give possibilities to increase efficiency in the developing countries.

Specialised veterinary advice when designing farm animal premises. Testing of new animal husbandry techniques and methods before marketing - A partly short-, partly long-term strategy

It is important that decision makers - both consumers and producers in the developing countries - realize that animal husbandry is a biological activity not always comparable with industrial production. One of the problems in the industrialized countries is that too few decision makers realize this.

In order to prevent diseases caused by environmental and managerial factors and improve animal health, preventive measures aimed at eliminating the disease generating factors must be undertaken. One method for doing this is veterinary advice when the individual farmer designs his animal housing and management. In some industrialized countries such advice is voluntarily performed in connection with building of farm animal premises.

Such active involvement for combating environment attributable diseases was legally implemented in Sweden in 1971 and is performed in animal hygiene by specially educated veterinarians. The result of this has been evaluated and shows that this is an effective contribution to preventing food losses through farm animal diseases caused by unsuitable housing and management factors.

Measures should be undertaken to arrange courses for interested veterinarians in developing countries in order to give them better possibilities to similarly help the farmers in a change-over to new animal husbandry systems and methods.

In a few countries, e.g. in Sweden, Switzerland and The Netherlands, new techniques have to be evaluated from the animal health stand point before they are approved for general use (Steiger, 1990). Methods for such evaluations have been elaborated (Ekesbo, 1984; 1988). In the long perspective such measures should be considered in developing countries.

OTHER MEASURES FOR PREVENTING FOOD LOSSES DUE TO NON-INFECTIOUS DISEASES

Genetic measures for avoiding disease and improving animal health - A medium- to long-term strategy

It is far more complicated to consider several traits, including health related factors, than just one or two production related traits in the breeding programme. However, there is no doubt that man today has better capabilities than ever before to improve both health and production of farm animals of the future through breeding programmes. It is important that these capabilities are utilized. In some countries there are on-going programmes designed to prevent diseases, such as mastitis or dystocia, by genetic means (Lindhé, 1986; 1990). In order to avoid some of the mistakes from the industrialized countries this possibility should be taken into consideration in the developing countries.

Genetic manipulation needs legislative measures - A short term strategy

Three requisites must be fulfilled before any animal, which is a result of genetic manipulation may be allowed to be used for farming purposes, i.e. is allowed to leave the limited sphere of research and enter the sphere of animal husbandry. First it must have been fully proved that the manipulation which was intended to be done has really occurred; that it is stable and that no integration has occurred into any other area of the genome than where it was meant to be located. The second requisite is that there must be secure and reliable screening methods available which make it possible to find and define each manipulated animal in a population, e.g. in a commercial cattle, swine, sheep or poultry herd. This is necessary for making follow up control investigations on manipulated animals which are released into commercial herds. The third requirement is that it should have been demonstrated that the manipulated genome, when introduced in a breeding system which permits recombination of genes, does not result in detrimental effects in the next generations.

In order to avoid losses by introduction of unsuitable animal material, the governments in the developing countries should consider the possibility of introducing legislation which fulfils the requisites mentioned here.

Need for preserving existing genetic material

We are apparently just in the beginning of a period of intense research and research progress in genetic manipulations. In such a situation it is of great importance that agreements are reached that local breeds of animals used at present for farming purposes should be preserved. Also, they must be preserved in populations of large enough size and, otherwise, in a way that makes it possible to again start breeding a variety that may not have been bred for several years, should this be found desirable.

Also here the national governments should consider the possibility of legal measures in order to guarantee the local breeds to be preserved.

Control of substances for increasing production traits - A medium-term strategy

A review of the literature indicates a great variation in response of farm animals to substances administered in order to stimulate growth or other production traits (Machlin, 1972; Bryan *et al.*, 1987; Eppard *et al.*, 1987; Evock *et al.*, 1988; Kievits *et al.*, 1988; Kronfeld, 1988; Kelley, 1989; Evock *et al.*, 1990; Dau and Bane, 1990). Such substances are engineered proteins or peptides produced by recombinant DNA technologies. This great biological variation in the response shows the risks if the handling and utilization of these substances do not take into account all factors in the animal and its environment which may interfere with the substance administered.

However, potential adverse effects of substances like bST, pST etc. and methods to prevent such effects seem to have received much less attention than the efficacy of such substances (Kronfeld, 1988; Sejrsen *et al.*, 1989). One problem is apparently that until now there has been a lack of funds for research regarding the risks. More financial resources have, for natural reasons, been allocated to investigate the feasibility of utilizing such substances. The problem is that research on risks must be mainly supported by public funds whereas the research on possible utilization is mainly commercially supported.

No substance should be allowed to be purchased for use on farm animals before independent scientific research has shown that the substance has no detrimental effects on stress, immune competence, disease resistance, reproductive performance and others as regards the health and welfare of essential biological functions of the species in question. Introduction and use of somatotropin in commercial herds before all health and welfare aspects are fundamentally scientifically investigated and defined could create and cause problems like some of those caused by uncontrolled use of antibiotics.

As soon as a testing system from the animal health and welfare standpoint for substances aimed at stimulation of growth or other production traits will be introduced in a number of countries, and thus accepted by the international scientific world, the results of such tests should be the foundation for mandatory national legislations regarding such substances in the developing countries. In this connection it is necessary to recall that, quite contrary to what is sometimes claimed (McClary *et al.*, 1990) production level is no measure of animal health (Ekesbo, 1966; 1988b) but must be taken into consideration when evaluating the effect of different factors on the animal's health and welfare (Ekesbo, 1988b).

Animal welfare legislation - A short term strategy

A national government can help its farmers to prevent food losses caused by animal diseases not only by legislation regarding contagious diseases or by legal measures proposed earlier in this paper. By implementing rules which prohibit bad husbandry methods it is possible to contribute to the prevention of animal diseases caused by unsuitable management or environment. Introduction of a national animal welfare legislation is a necessity for supporting the farmer to give his animals good treatment. Examples of issues which require supporting legislative rules are the following:

Antibiotics in feed must not be used as a routine in order to compensate for bad environment.

Purchased feed shall be treated in such a way as to effectively prevent its causing, or spreading, diseases.

It must be made very clear that surgical or medical measures should be reserved for the sick animals and should never be used as a general practice to compensate for inadequate environment, including management. For example, tail biting and pecking must be prevented by correcting the environment and not by using, as general practice, tail docking or beak trimming.

Traditional animal husbandry contained "silent" ethical elements regarding the relationship between man and farm animals. Such guidelines, written or unwritten, will always be essential for animal husbandry. As the transfer of biologically based unwritten husbandry tradition from generation to generation is progressively weakened, or sometimes does not even exist any more, the animal husbandry tradition for each species must be replaced by detailed guidelines in the form of national animal welfare law and provisions designed to fulfil the same purposes. Such guidelines facilitate the understanding in society that animal husbandry is a biological activity and for that reason in some respect has to follow other rules than those for industrial production.

Such national legislation shall at least fulfil the provisions, based on scientific knowledge and practical experience, now elaborated by the Council of Europe Standing Committee on Farm Animal Welfare. Such national provisions have to support the results of research and education which must be the base for a possible and realistic improvement of the health and welfare in current and future animal husbandry. They also have to remind man of his ethical responsibility with respect to his relationship with farm animals.

The Council of Europe is responsible for elaborating international conventions regarding ethical issues like civil rights and animal welfare. With regard to farm animals those conventions regarding international transport, slaughter and especially that regarding animals kept for farming purposes (Council of Europe, 1976) are of interest. Up to 1991, 18 countries of the 25 in the Council of Europe have ratified this convention. Also EEC, as a supranational organisation, has ratified the convention.

Article 3 of the convention specifies that "Animals shall be housed and provided with food, water and care in a manner which - having regard to their species and to their degree of development, adaption and domestication - is appropriate to their physiological and ethological needs in accordance with established experience and scientific knowledge." According to article 8-13, a Standing Committee in the Council of Europe shall elaborate detailed rules for animal husbandry from the animal welfare point of view for each species. This Committee was established in 1979. These rules have to be transformed into binding rules via law or otherwise by means of administrative ordinances in those member countries which have ratified the convention. Also EEC will adapt its common rules. Until now such rules have been elaborated and adopted by the Committee for cattle, swine, egg laying hens and fur animals.

In the Standing Committee all nations which have ratified the Convention have full membership, they are "contracting parties". Ratification in most countries means a decision by the national parliament. Countries which have not ratified the Convention have the status of observers, e.g. Austria, Hungary, Turkey, and others. Outside Europe, Australia, U.S.A. and Thailand have observer status. Developing countries should consider the possibility to ask for observer status in the Standing Committee in order to get information of the process regarding international animal welfare legislation.

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FOOD LOSSES DUE TO DISEASES RELATED TO ANIMAL HYGIENE DEFICIENCIES AND PROGRAMME FOR THEIR REDUCTION

by

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SUMMARY

Although in the developing countries in 1989 the human population was 76%, cattle 68%, buffalo 99%, pig 59%, sheep 52%, goat 94%, chicken 54% and duck 92% of world population, food production from animal origin was very low. In comparison with production in developed countries, the developing countries produced only 19% of meat, 14% of milk and 26% of the world's food supply from the above animal population.

Efforts have to be made to increase animal production by reducing the losses due to diseases related to animal hygiene deficiency.

Food losses due to diseases related to animal hygiene deficiencies are mostly caused by ignorance of farmers, lack of education and the poor condition of farmers who are unable to make substantial improvements.

The strategy for reduction of losses consists of control or eradication of the major infectious diseases prevailing in an area/island/country by government services, with the active involvement of farmers.

Extension for farmers through farmer's groups is the next step to be taken, without neglecting the role of woman in agriculture production.

Through the formation of farmer's groups, the government concerned could assist subsistence farmers by provision of livestock credit schemes and extension and veterinary services, to enable them to become semi-commercial and commercial farmers, thus increasing their share of income from livestock. Diseases which may block further management improvement, e.g. gastro-intestinal helminths or fascioliasis, should be given first priority for control with the help of government veterinary services.

Incorrect and unbalanced feeding, as well as under-feeding, are two of the causes leading to disease occurrence which should be tackled.

Extension materials should include, not only the technical aspect of controlling diseases due to animal hygiene deficiencies, but also the socio-economic impact of losses.

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After the farmers have improved their farming system from subsistence into semi-commercial and then commercial farming, they need more professional veterinary services which cannot usually be provided by government services. Privatisation of veterinary services will help the development of semi-commercial, commercial and industrial farming.

With their new status, the farmers themselves are able to minimize losses due to diseases related to animal hygiene deficiencies. However, the governments concerned, and FAO, could assist in the most important areas, e.g. extension, feeding improvement and mastitis control, gastrointestinal helminth control and improvement of post harvest handling.

INTRODUCTION

Developed Versus Developing Countries

Food is one of the main basic needs of human beings. The food requirement in 1986 - 1988, illustrated in average daily calorie supply for the population in developing countries, was 2,434 calories (2,214 of which from vegetable products and 220 from animal products) with some people consuming less than 2,000 calories, resulting in hunger and malnutrition. However, the population of developed countries have largely enough to eat with an average daily supply of 3,399 calories (2,371 of which from vegetable products and 1,028 from animal products).

In 1989, out of 5.20 billion world population, 24% (1.24 billion) lived in developed countries and 76% (3.96 billion) in developing countries. Only 8.7%, out of a 48% economically active population of developed countries, were actively engaged in agriculture; while in developing countries 60.2% out of a 43% economically active population were engaged in that field.

The above figures indicate that, in general, agriculture farming in developing countries is not yet efficient. In 1989, in comparison with the world livestock population in this region, the cattle population was 68%, buffalo 99%, pig 59%, sheep 52%, goats 94%, chickens 54% and ducks 92%. However, due to the low production per unit, the availability of main animal products during 1989 - 90, in comparison with developed countries, was: meat, 16 vs. 82 kg. (19%), milk, 42 vs. 295 kg. (14%), and eggs, 4 vs. 15 kg. (26%).

Developing Countries in the Asia and Pacific Region

This region, with a human population of 2,735,438,000 (52.5% of world population), has the highest population of buffaloes, goats and ducks. In comparison with the world livestock population, the population of cattle was 28%, buffalo 96%, pigs 48%, sheep 20%, goats 51%, chickens 33% and ducks 88%. Livestock not only have economic value, but also social, cultural and religious significance in the life of the people. Farming is characterized by subsistence and small-holding type of farming, with an average of very small land size and landless farmers.

Livestock still plays a big role in food crop production as draught animal power and carriage-hauling, as well as producing manure for fertilizer. In addition, the ruminants can convert crop residues and other agricultural by-products into valuable food such as meat and

milk. Besides the development of commercial poultry farming, native chicken rearing among small farmers is still the main source of meat and eggs for the rural population. With a birth rate of 2.8% in developing countries in Asia, and more than 3% in the Pacific regions, the provision of enough food supply for the population in the region is becoming more difficult.

With the increase in standard of living, due to the improvement of the economic situation for most of the region's population, the demand for food from animal origin (meat, milk and eggs) is also increasing rapidly. Even though the fulfilment of the standard food requirement for their own people has not yet been met, the need for foreign exchange has forced governments not only to increase livestock production for domestic demand, but also for export. This situation is caused by the fact that the demand for certain products of some developed countries has increased tremendously due to the increase in their buying capability, necessitating the import of these products from other countries.

In producing food from animal origin (meat, milk and eggs), livestock production could be interpreted as a biological industry in which there is interdependency, interrelation and interaction between the farmer, livestock, land, environment and technology.

At first, only subsistence livestock farming was found. With the increase of demand and market development, more complex farming towards a commercial system started to develop, e.g. semi-commercial, commercial and industrial production.

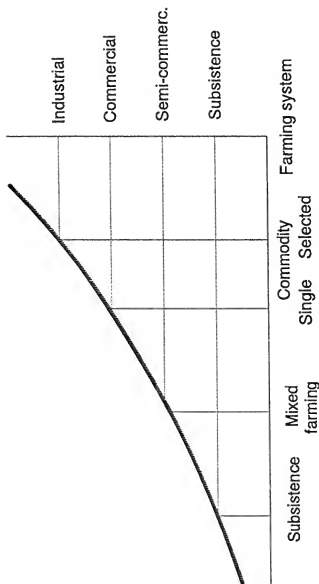
Types of livestock business patterns could be classified as follows:

1. **Subsistence Farming:** Farmers generally grow food crops and rear a few livestock as a side-line to produce enough food for their own needs. Income generated from livestock is around 30% or less.
2. **Mixed Farming (semi-commercial farming):** Farmers keep livestock as a second business in their farming system and income generated from livestock is about 30 - 70% of total income.
3. **Commercial Farming:** Livestock is the main income source and will consist of 70 - 100% of the farmers' earnings. Livestock may be the main or significant business of their farming system.
4. **Livestock Industry:** Livestock business established as commercial farms which rear livestock on an industrial basis (specialized farming). Income obtained from the commercial farm can be 100%. This largely depends on the output of livestock farming.

DISEASES RELATED TO ANIMAL HYGIENE DEFICIENCIES

One prerequisite of successful livestock production in developing countries is the control of epidemic diseases. In conducting the programme, the technical approach only did not solve the problem. For instance, in the FMD eradication campaign, the stamping out method has not worked well in Malaysia in the 1978 outbreak because, even though the farmer would receive compensation for slaughter of infected/contact animals, the close

THE RELATIONSHIP BETWEEN FARMING SYSTEM & LEVEL OF ECONOMY



relationship with their animals forced farmers to hide livestock in the forest to avoid slaughter. Ultimately, the government had to compromise and conduct a vaccination programme. Many governments have not effectively controlled most epidemic diseases and farmers have to increasingly contend with endemic diseases which are regarded as a normal part of the management system.

In general, the effect of animal diseases in developing countries could be classified as:

1. **Reduction in yield of product:** Animals affected by a disease may produce less usable product than animals free of that disease. In the case of *Fasciola hepatica* infection, lower feed conversion or reduced feed intake may be caused.
2. **Reduction in reproductive performance:** Animals affected by disease may have reduced fertility or fecundity due to either direct effects on reproductive function or indirect effects through reduced body weight.
3. **Reduced productive life:** Animals affected by disease may have to be replaced earlier.
4. **Reduced quality of products or services:** These may also be the result of the presence of disease.

Therefore, the general principle is that diseases may exert their effect in a number of ways and diseases can actually "block" or reduce the value of improvements in animal husbandry, feed quantity or genetic value. For example, improvement in feeding of animals infected with *Fasciola hepatica* will not give as good a result as expected unless the liver fluke problem is also controlled. In this respect, disease is a different and potentially more significant way of improving livestock production than husbandry improvement. Disease control can "make or break" the effect of other improvements.

Since animal hygiene of industrial and commercial farming, e.g. commercial poultry breeding/production farms are usually in good condition, the discussion will be focused on semi-commercial (mixed farming) and subsistence farming systems, which constitute the biggest farming activity of small farmers in the region.

Native Chicken Backyard Farming

In rural areas, native chickens are raised extensively by farmers. The chickens live freely around the house and neighbouring yards. Farmers do not provide feed, housing, medication or vaccination against infectious diseases.

The most common diseases are Newcastle disease (ND), fowl pox, pullorum, mycoplasmosis, coccidiosis, leucocytozoonosis infection and external and internal parasites. In addition, animal hygiene deficiencies found are malnutrition (both insufficient feeding and specific nutrient deficiencies), contaminated water supply and lack of appropriate management systems.

Without a ND control programme the biggest loss is caused by this disease, especially in young birds under two months of age. Morbidity is 50% with mortality usually 100%.

Besides the dead birds, losses are also caused by reduced egg production of up to 50%. In Indonesia, in 1990, the estimated loss due to ND was US\$11 million.

Diseases in the field are always found in a mixed infection. A field study on native chickens in Indonesia revealed that morbidity from fowl pox was 18.2%, pullorum 14.9%, mycoplasmosis 64.6%, coccidiosis 9.1%, and leucocytozoonosis 29.8%. Internal parasite infestations from large roundworms, tapeworms, or a combination, caused losses of up to 94.9%. In a study in Indonesia in 1989, it was found that mixed worm infestations caused a body weight reduction of 144 - 202 gram/bird (11.52 - 16.16%).

During the egg marketing process from the producer to the consumer, in a study in five provinces in Indonesia in 1988 it was found that losses averaged 3.86% in native chicken eggs, 2.05% in commercial chicken eggs, and 3.92% in duck eggs.

Duck Farming

Most ducks are raised under traditional farming systems. Traditional farming is by herding ducks into open post-harvest rice fields to consume left over rice, other seeds and insects in the marshy land. Some farmers have started to raise ducks in semi-intensive or intensive systems where they are kept confined, with feed and water provided.

The traditional husbandry system causes many disease problems, e.g. aflatoxicosis with mortality of 30 - 44.3% and egg production decreases to 50%. Other diseases usually found are salmonellosis and pasteurellosis, with mortality rates in the adult of 23% and under four weeks of age ducklings of up to 100%; duck pox, with a prevalence rate of 10 - 30%, and sinusitis, with an infection rate of 4 - 100%. No financial data on the losses caused by these diseases are available.

Goats and Sheep

Farmers raise goats and sheep by providing simple elevated or soil floor pens. They let the animal graze freely or keep it tethered during the day. In the afternoon/evening the farmers provide additional cut and carry grass or certain tree leaves. Some farmers give salt and rice bran or other cereals as extra feed, especially to milking ewes.

The most common diseases found related to animal hygiene deficiencies are orf (contagious ecthyma), scabies, fascioliasis and gastrointestinal worms. A study in two provinces in Indonesia in 1982 revealed prevalence rates for orf of 21.4%, scabies, 23.3%, gastrointestinal worms in goats, 89.4% and in sheep, 96.3%. Another study in Indonesia in 1987 estimated that body weight loss in sheep due to combined internal parasites was 17.75 - 24.77%. It was estimated in 1990 that the annual loss due to haemonchosis in Indonesia was US\$1 million and scabies US\$3.6 million.

Beef Cattle and Buffaloes

Small-holder farmers keep cattle and buffaloes to help in the field (ploughing rice fields), hauling carriages in rural areas, as a savings bank, and for meat when the animals become too old. A simple barn, usually attached to the farmer's house is provided and the

animals are allowed to graze along river banks, roads or unused rice fields in the village during the day. In the afternoons farmers bathe animals in the river and cut and carry grass or hay to be fed in the barn. No additional feed is given to the animal except sometimes to calving cows and animals kept especially for fattening purposes which are given rice bran or other cereals, waste agriculture products, molasses and minerals.

Diseases related to animal hygiene deficiencies are gastrointestinal helminths, fascioliasis, blood parasites, (theileriosis, anaplasmosis, babesiosis, trypanosomiasis), bloat, cascado and ringworm. A study in Bali, Java islands and Lampung (Southern part of Sumatra) revealed a prevalence rate of *Neoscaris vitullorum* in Bali cattle less than four weeks of age of 75% while in Java local Brahman or Ongole cattle showed 46 - 70.4%. The haemonchosis infection rate in Lampung for young cattle was 23% and in adults 8.8%. Average mortality, morbidity and reduced growth rates due to *Fasciola gigantica* in Indonesia are thought to be around 1%, 30% and 20%, respectively. It was estimated in Indonesia that the annual cattle loss caused by fascioliasis in 1985 in cattle was US\$6.5 million. Another report from Thailand showed that the prevalence rate for *Fasciola gigantica* in buffaloes was 50 - 63%. The prevalence rates for blood parasites in a South Sulawesi study showed for cattle and buffaloes respectively, theileriasis, 1.32% and 9.99%, trypanosomiasis, .01% and .03%, microfilaria .052% and .02%, in cattle, babesiosis, .052%, and in buffaloes, anaplasmosis, .02%. There were no signs of disease in these animals but whenever there were heavy stress symptoms (lack of feed, too long dry season, too heavy work burden), clinical disease appeared. Cascado, a disease caused by the nematode *Stephanofilaria spp.* which affects the skin and which used to be found in North Central Sulawesi (prevalence rate 90%), West Kalimantan (prevalence rate 80%), and West Sumatra (prevalence rate 100%), was detected in one dairy cattle herd in Java, Boyolali district, to have affected 65% of over two years old cattle, and 3% of the young stock. Ringworm, which was suspected to have come with the importation of Friesian Holstein cattle from Australia, was detected in a dairy cattle herd in Central Java with a morbidity of 56% in imported cattle, 33% in local and imported cattle kept together, and 9% of local cattle.

In a study in Java, mixed infections of three kinds of helminths (nematode, cestode and trematode), the prevalence rate was 32.73%, which caused an estimated meat production loss in Ongole cattle of 8.55 - 17.90%.

Great losses may also occur due to animal hygiene deficiencies resulting in poor feeding if the management is such that the farmer is unable to detect oestrous on time or animals are anoestrus due to hypofunction of the ovaries.

Dairy Cattle

The majority of dairy farming in the region is conducted by small-holder farmers who raise several dairy cattle with the help of the family. With a very simple barn, the cattle are fed either by pasture or improved grass cut along roads, rice fields, the garden or with other agricultural wastes. In addition, concentrates, which are commercial feeds, prepared or mixed by farmers themselves, are given to cows. In Indonesia almost all farmers still do milking by hand. The milk is sent to milk collecting centres belonging to farmer's dairy cooperatives, then to the milk plant, and the farmer is paid based on the milk quality.

Based on the 1990 Annual Report of the Indonesian Dairy Cooperatives Union, diseases related to animal hygiene deficiencies found among their members was 50% related to digestive tract problems (37% non-parasite, 8.77% infection and 4.12% parasite), 13% mastitis, 8.48% locomotor system, 6.27% respiration system, 5.71% skin problems, 4.98% nervous system and 4.49% metabolic problems. The 37% cases of non-parasite digestive tract problems consisted of 42% indigestion, 24% anorexia, 19% bloat, and 10% diarrhoea.

With regard to problems related to reproduction, it was found that from the total cases in 1990 there were 72% related to calving complications (69% of which was *retensio secundarium*), 21% to pathological conditions (78% of which were endometritis), and 8.1% to hormonal disorders (51% of which were hypofunction of the ovaries). These figures indicate that food quality and quantity were insufficient and there was inadequate post calving treatment.

In Indonesia the prevalence of clinical mastitis was found to be 10.6 - 24.3%, while subclinical mastitis was 36.9 - 67%. Milk production losses have been estimated in Indonesia in 1984 at 10% and 14% respectively from clinical and subclinical mastitis or US\$19 million annually from the national herd. The management factors that influence this high figure usually are: type of barn floor and method of cleaning it, udder and teat sanitation, quality of water used for cleaning, use or non-use of cloths in cleaning the udder, and presence or absence of hand-washing before milking.

In a study (1990) on the loss to a farmer due to delay in mating dairy cows, it was calculated that US\$1.70 per day per cow was lost.

In a study of 23 dairy farms in Bogor in 1985, it was revealed that mortality rates of calves and cows were 11.6% and 5.4% respectively.

The milk loss during transportation from the farmer to the sub-collecting centre and then to the collecting centre and milking plant was calculated, in a study in Java, to be 5.75%.

PROGRAMME FOR REDUCTION OF LOSSES

1. In the livestock production process, the farmer, assisted by his family, is the key to all activities. The farmer has to be motivated to do something or to change his farming system. Because the majority of farmers are small-holder farmers, they need technological transfer to improve their farming business to become more commercially oriented. The aim of extension is basically to increase awareness and change the attitude of farmers to accept technological transfer in order to improve their farming business. Since most farmers lack capital and education, the best approach would be through the formation of farmer's groups.
2. The education background of the farmer could give an indication of how well they absorb the extension programme. In a study in 1988 in Java among dairy farmers, it was revealed that 3 - 9% had no formal education, 2 - 40% had not finished elementary school and 20 - 70% had graduated from elementary school.

3. Women make a great contribution to livestock farming, especially in poultry, small ruminant rearing and dairy farming. In the formation of farmer groups, there are also special women farmer groups as well as young farmer and men farmer groups. In several successful native chicken and duck farming groups in Indonesia, the majority of members are women. However, it is a fact that their position is not yet optimal and by law is not yet fully recognized. In receiving livestock credit, only the farmer, as head of the family, has the authority to sign credit contracts from banks.

4. Type of farming also plays an important role in developing motivation of the farmer to reduce losses and improve product quality. In subsistence farming, the livestock enterprise is too small to be efficiently and economically run. When farmers change their farming system into a semi-commercial, then a commercial system, the market demand for good quality livestock products will force farmers to make the necessary improvements in their farming system/animal hygiene to avoid losses.

In semi-commercial farming such as fattening and dairy farming, certain preventive measures have to be given first because the animals are confined in barns, e.g. a deworming programme, thus ensuring that worm re-infection can be avoided, as well as any subsequent worm infection which might "block" any other improvement programme.

5. Changes in management should include improvement of oestrous detection, artificial insemination service and feeding. Feeding should be matched with available resources in the area concerned. Incorrect, unbalanced feed and underfeeding caused great losses in production and reproduction of animals.

6. In dairy farming, losses due to subclinical mastitis are mostly caused by deficiencies in animal hygiene, incorrect milking and milk handling. In addition to extension programmes, the payment of milk based on minimum standard quality and provision of a bonus above the standard is one alternative to stimulate farmers to improve dairy hygiene.

7. In dealing with and controlling many other diseases which cause losses, especially for semi-commercial and commercial types of farming, availability of veterinary services is very important. The development of the livestock industry in the last two decades has taken place so fast that the government veterinary services alone were unable to cope with provision of the necessary services to supply drugs, equipment, laboratory, budget and personnel (veterinarians, veterinary assistants, inseminators and other technicians). This situation has stimulated the development of private veterinary practice, hiring veterinarians in dairy cooperatives, drug and feed industries, breeding and other commercial farms.

8. Since losses due to parasite infection are much higher than infectious diseases, the need for gastrointestinal helminth control programmes require many anthelmintics. These animal drugs should be made available in rural areas to enable farmers to purchase them easily. Some farmers use traditional medicines which are available in their area for gastrointestinal helminth control.

DISCUSSION

The prerequisite of any livestock development programme is the control and/or eradication of major infectious diseases prevailing in an area/island/country. This activity should be conducted by the government since it is related to other regulatory measures, e.g. livestock movement, quarantine, stamping out, and other law enforcements. However, full participation of the farmers concerned is needed through farmers' groups. A thorough extension programme for the involved farmers is very important before the programme is launched. The farmer should be asked to share the cost of the programme, e.g. cost of the vaccine or operational costs. The farmer's feeling of responsibility will be aroused and this will be a part of his education process.

Native Chicken Backyard Farming

1. The biggest loss related to animal hygiene deficiencies is due to Newcastle disease. This could be overcome by a regular vaccination programme. Once the disease has been controlled and no mass casualties occur, inputs for controlling other diseases and improved feeding and other management improvements could easily be done. The governments in the region have tried to conduct such programmes for many decades, however, the results are not yet satisfactory.
2. The high growth of commercial chicken (layer and broiler) farming does not stop people's preference for native chicken meat and eggs. These products demand higher prices because of the traditional eating habits and belief of most people in the region. A request to export native chicken meat to Japan from Indonesia has still not yet been possible to realize.
3. With very low investment cost, native chickens have become a part of the rural farmer's life. The meat and eggs produced could fulfil their needs in a subsistence farming system. In the past the seasonal Newcastle disease outbreaks and losses caused did not bother the farmers because they have other sources of income. However, they have no training in better production methods and there is a lack of vaccine availability.
4. The experience over several decades of the Indonesian government to provide free Newcastle disease vaccine and vaccinators to undertake the vaccination programme was unsuccessful. Since the total number of native chickens is approximately equal to that of the human population, which now numbers 187 million in Indonesia, the budget was only sufficient to provide 15% of the amount of vaccine needed for the whole country. A new strategy has been launched since 1988 with a project called the Native Chicken Intensification Programme (INTAB). Principally, the project is a mass guided one in which the key to success is the full participation of farmers who have to organize themselves into farmer groups. Vaccine, to start with, is provided free by the government and later must be paid for by the farmers. Private companies provide vaccine sales and services to rural areas. The livestock services which organized the project cooperate with extension services, heads of village in subdistricts, districts, the governor and other public services. In addition to vaccination, the provision of simple housing (which facilitates the vaccination programme),

extra feed from waste agriculture products, and marketing of meat and eggs, are organized within farmer groups. Since chicken raising is conducted near the house, women are those actively involved in the daily activities.

In one of the poor districts in Yogyakarta Special Province, Gunung Kidul, the INTAB Project has been able to reduce the poverty rate from 60% to 16% since the launch of the programme in 1988.

A new ND vaccine with VH4 strain, administered by mixing vaccine in feed instead of injection, has been developed in South East Asian countries. This vaccine is still undergoing field trials and will hopefully give better results in the future.

Goat, sheep, beef cattle and buffaloes

1. Losses due to diseases related to animal hygiene deficiencies in small-holder farms could be reduced by:
 - (a) development of markets for products produced by these farmers.
 - (b) selection and provision of feed available in the areas which match the type of farming.
 - (c) organization of farmer's groups into cooperatives.
 - (d) provision of extension to farmers on the improvement of farm management.
 - (e) provision of animal health services, including veterinary drug availability, to farmers.

Dairy cattle

In dairy farming, improvement of feeding is the first step to be taken. The low level of farmer education and the need for better extension are reasons for lack of quantity and quality of feed. This lack has caused many disease problems. However, sometimes the farmers are very poor and unable to feed cattle properly. The preventive measures which should be taken consist of deworming, hoof trimming, mastitis control and post-partum treatment to avoid problems in reproduction. Proper management in milking the cow, including teat dipping and dry cow treatment, are also very important.

The improvement of oestrus detection and A.I. services could be done by improving the farmers' recording system, which should be a part of the dairy recording system in the group/cooperative.

To ensure the above improvements, an intensive veterinary service system is needed for dairy farmers, which could be provided by dairy cooperatives for their members.

CONCLUSION

Food losses due to diseases related to animal hygiene deficiencies are mostly caused by farmers' ignorance, lack of education and the poor condition of the farmers who cannot afford to make substantial improvements.

The strategy for reduction of losses consists of control or eradication of major important infectious diseases prevailing in an area/island/country by the government services. The programme should actively involve the participation of the farmers.

Extension for farmers through farmer's groups is the next step to be taken including the role and potential of women, who constitute 50% of the labour force in rural areas. This has so far not been fully recognized and needs to be included in the extension programme through women farmer groups.

Through the farmer groups, the government concerned could assist subsistence farmers by provision of a livestock credit scheme, extension and veterinary services, to assist these farmers to become semi-commercial and commercial farmers so that their share of income from livestock will be increased. Diseases, which may block further management improvement, e.g. gastrointestinal helminths and fascioliasis, should be the first priority to be addressed with the help of the government veterinary services.

Incorrect and unbalanced feeding, as well as under-feeding, are sources of disease problems which should be tackled.

The extension materials should include, not only the technical aspects for controlling diseases due to animal hygiene deficiencies, but also take into account the economic impact of the losses.

When farmers have improved their farming system from subsistence into semi- and then commercial farming, they need more professional veterinary services, which usually cannot be provided by the government services. Privatization of veterinary services will help the development of semi-commercial, commercial and industrial farming.

RECOMMENDATIONS

1. Developing countries have to give more attention to programmes for increasing native poultry production as a source of animal protein and income for rural people.
2. FAO should make a study on the effectiveness of the role of extension with farmer group formation in developing countries in reducing food losses due to diseases related to animal hygiene deficiencies.
3. Developing countries which have a dairy farming development programme should formulate a national mastitis control programme.
4. FAO should make studies on food losses due to gastro-intestinal helminths and post-harvest losses from handling of meat, milk and eggs in developing countries.

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FOOD LOSSES DUE TO NEO-NATAL MORTALITY AND PROGRAMME FOR THEIR REDUCTION

by

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The topic assigned to the author for discussion at this meeting was food losses due to non-infectious neo-natal mortality and a programme for their reduction.

In general terms, neonate refers to the period of time from birth until 30 days of age. Since much of the data available is based on mortality rates up to the third or fourth month of age and, in some cases, as much as one year of age, some guess-work was required for this presentation. Items are documented where possible. However, not much specific information is available on non-infectious diseases. The author finds it very difficult to isolate non-infectious conditions from those of an infectious nature. For example, he would consider failure of passive transfer of immunoglobulins as a non-infectious process, yet the ultimate demise of the neonate would be from an infectious cause. Due to this, all diseases that affect the neonate are being considered in this presentation if they have any non-infectious character whatsoever.

In an effort to quantify neonatal losses a search of available literature was made. Primary attention was paid to cattle, small ruminants, including the South American camelids, and swine. All geographical areas were looked at to obtain a comparison to the problem as it exists in the tropical and semi-tropical environments. Most data involved ages up to four months so some interpolation of data was required. Following are the findings by species.

CATTLE AND BUFFALO

There were three rather specific references where actual percentages were used. In India, losses during the first 30 days on 116 cattle herds and 24 buffalo herds were 55.79% among cattle and 51.72% in buffalo (1). Digestive disorders made up 32.21% of the total losses in cattle and 49.66% among buffalo. It was assumed that this was all disorders indicating gross symptoms of diarrhoea or any other gastrointestinal tract (GIT) sign. Most of these well could have been infectious in nature but very probably involved failure of passive transfer (FPT) as this is by far the most common initiating cause of neonatal death in western livestock and the author would have no reason to suspect otherwise in the rest of the world. Continuing with this study, 32.74% of calves and 20.46% of buffalo exhibited signs of respiratory disease. Again, these were probably infectious, but most likely related to FPT.

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Totals of weak, debilitated and anaemic calves were 6.95% in cattle and 6.9% in buffalo which were third on the list. This could also involve FPT or poor nutrition of the dam, resulting in poor milk production. It could also involve external parasite-induced losses of blood. The last class differentiated was called septicemia, pyrexia, and toxemia and consisted of 4.42% in cattle and 5.75% in buffalo. The author does not know how to interpret this last set of data. 11% and 16% respectively of the rest were listed as undiagnosed.

In another study in Sri Lanka (2) mortality due to haemorrhagic septicemia was tabulated. In cattle calves the death rate varied from 4% - 50% and in buffalo calves 8% - 28.4%, with a mean on both of 16.8%.

To contrast this a Canadian study (3) used 56 herds examining risk factors causing diarrhoea in beef calves in the first 30 days of life. The relationships mentioned here were increased number of heifers in the herd, poor drainage in nursing area, limited shelter, large calving area, and cows and heifers being wintered together. All these are management problems and probably related to conditions of the body fat stores in the younger dams and FPT to the calves.

A summary of the large ruminant data is as follows:

Losses in cattle	4% - 56%
Losses in buffalo	8% - 52%
Median per cent for both species	30%

The highest percentage of losses occurred from:

<u>Cattle</u>		<u>Buffalo</u>
33%	Digestive Disorders	50%
33%	Respiratory Disorders	21%
7%	Weak, Debilitated, Anaemic	7%
16%	Other conditions	32%

(Note: some animals showed signs of more than one category)

This would then indicate that at least 70% of deaths involved gastrointestinal and respiratory symptoms, as well as debilitation.

Cattle studies in the U.S. which indicated management factors causing increased neonatal death were:

- Young dams
- Wet quarters
- Poor shelter
- Insufficient attention at calving
- Poor nutrition, especially heifers

All above causes relate to management problems and FPT.

SMALL RUMINANTS

General information on perinatal losses of lambs varied greatly from place to place, between seasons, and in relation to the management practised, with an overall mortality in sheep in Ghana (23) of 20% - 95%. The mortality rate in lambs of native sheep of the Orkney Islands (United Kingdom) was 31% due to trauma from bolting (trampling), 23% from hypothermia, 14% from starvation, 11% from gastrointestinal disorders, and 6% from stillbirths (4).

Mortality of three breeds of sheep in the Caribbean (5) from birth to weaning was 19.1%, 15.8%, 10.8% respectively.

An Australian study (6) indicated lowered birth weight and below maintenance feeding regimens to the ewes increasing mortality in the first week. This was primarily due to weakness of the lamb, starvation, mismothering and desertion. Interestingly enough, in nearly all references enterotoxaemia did not appear to be a problem, yet this is the most common vaccine given to sheep.

A U.S. range study involving 12,000 ewes (7) indicated an overall loss of 7.18%. The previous years's estimate was a 30% death loss. Enteritis made up 38.4% of losses, followed by starvation, 21.2% and stillbirths of 17.3%. These three items were 76.9% of all losses. These data agreed with other U.S. data, according to the author, that starvation and stillbirths constituted the most common cause of lamb mortality in the U.S. range sheep flock.

An Australian report (8) indicated a 25% loss of lambs during the first seven days in Australia and 15% in New Zealand. Also, 90% mortality occurred in the first three days. Birth losses were from congenital malformations, nutritional deficiencies and infections, plus birth injuries. Those losses after the birth process were starvation, including FPT, mismothering and exposure.

When goats only were reported fairly similar patterns emerged. In an Indian study (9) an 18% death rate in the first 30 days was reported. Infectious diseases were most common, however, anaemia and disability were fairly common. Another Indian study (10) indicated that small kids, less than 2 kg. were the majority of those that died during the first week.

Wilson (11) indicated an overall kid death rate of 30% in Africa. On a Maasai ranch group he also reported a 28.6% mortality in goats.

Grey *et al.* (12) in Botswana indicated an overall death rate during 2½ years of between 23% - 67% per year. The author's personal experience in this same area supports these data.

Other mortality reports, i.e. from Cameroon (13), reported lamb mortality of 47% with causes being diarrhoea, ticks, cough, emaciation, bottle jaw and lice as primary signs, and in goat kids, 21%, with cough ticks, diarrhoea, nasal discharge and emaciation being most common.

In Nigeria (14) sheep losses of all ages were 31% and in goats 46.3%. It was indicated that Peste des Petits Ruminants vaccination greatly decreased this loss in following years.

External parasites can cause serious effects. Fleas caused severe anaemia in sheep and goats in Nigeria (15). This paper reported on packed cell volume (PCV) studies which indicated that light infection caused a PCV of 27.9%, medium infestations 23.8% and heavy infestations 15.1% in sheep.

A Botswana study (16) indicated a highly significant increase in the PCV of goats at days 28 and 56 of post treatment with a therapeutic dose of Ivermectin. Death losses, most likely due to lice infestation, were very common during the first few months of life.

Hypothermia, starvation and exposure, coupled with accompanying failure of passive transfer, were listed as the most common causes of neonatal losses in small ruminants. Total losses in the first 30 days of life in the developed sheep and goat production areas are between 10% - 35% and 25% - 50% of all preweaning losses (17) world-wide.

Lambs can survive without nourishment for up to four days in warm weather without other severe stresses. However, severe weather stress can deplete reserves of energy in 6 - 16 hours. Most data is derived from North America, Australia and New Zealand where more severe weather occurs. However, wet, cool weather can also cause weather stress and lack of colostral antibody protection greatly reduces the ability to withstand infectious diseases.

SOUTH AMERICAN CAMELIDS

Indications are that *Clostridium perfringens* causes up to 50% of mortality in alpacas (18). In another report FPT appears to be the most important cause of neonatal mortality in Peru (19).

It is suspected by the author that the number of losses in these species is similar to those of other small ruminants.

SWINE

Survival of pigs in Britain (20) indicated that birth weight and litter size were related to immunoglobulin absorption and thus, survival rate. Small pigs in large litters tended to have higher losses of up to 20% or more.

In a Bolivian study of swine raised in the traditional manner (21), it was found that improved production and management practices, i.e. nearness to veterinary services, adequate extension advice and animal health products, increased productivity and decreased losses greatly.

Piglet Mortality in Relationship to Availability of Services

	Nearest	Median	Farthest	Total
Mean litter size	8.4	7.5	6.6	7.6
Mortality to weaning %	19.0	30.0	50.0	30.6
Mortality at 2-5 months %	6.7	9.6	19.0	11.2
Mean litter size @ 5 months	6.4	4.6	2.7	4.7
Pigs per sow per year	10.0	7.8	4.6	8.0

Existing available documentation is very helpful in looking at the past to plan for the future. It is obvious that increasingly more specific information is needed.

Education at all levels appears to be the most important lacking item. However, in the third world farmers often do not recognize neonatal losses as true losses but consider them as normal, or expected.

In many areas of the world, animals dying of disease are just a household source of meat. With increased emphasis on human health services this practice is likely to decrease. Fortunately, religious taboos have helped prevent this in many areas.

Lack of education is not limited to the small village livestock producer. Wilson (22) commented that "Lack of understanding of economic and social values of small ruminants by politicians, developers and scientists undoubtedly restricts production and education programmes." This observation is wholeheartedly supported by the author whose experience while working in Botswana was that, on many occasions, when asked what work he was carrying out, and replying that he was researching goat diseases, conditions and production, the most common reply, made by scientists, development workers, knowledgeable and well-educated people was that "they sure hoped he did not find a way of keeping them alive!" The author's usual reply, before losing the audience's attention, was to supply information on their value to small farmers, the amount of milk and meat these ruminants produced for villagers, and how dependent the latter were on these ruminants. The audience, however, would tend to move away from someone having such interests in goats and sheep.

No consideration has been given to predator problems in this paper. Although it is recognized that these problems exist and are significant in certain areas, it is felt that this should be dealt with as an individual problem rather than a policy consideration.

THE PROBLEMS

In an attempt to further reduce this data and arrive at a workable unit it appears that the following problems can be deduced and assumed.

1. It is almost practically impossible to disassociate infectious from non-infectious diseases during this period of life.
2. There is a lack of good quantitative data available on food animal losses by specific diagnosis, both infectious and non-infectious. Most data is derived from sources other than veterinarians and a great deal of it from surveys sent out to farmers and not from complete or adequate diagnostic surveys. Most of the more complete available data comes from a central diagnostic laboratory and may, or probably may not be, indicative of the situation in rural areas.
3. Neonatal losses in food animals in the developing countries will probably be between approximately 25% - 50% of potential production. Although a few countries will be lower, many will show a higher percentage. Losses will vary both from year to year and season to season, depending on when the data was collected.
4. Losses will vary depending on management and husbandry ability, climatic conditions, and availability of feed resources both during gestation and lactation.
5. Failure to obtain nourishment (starvation, FPT, mismothering and environmental inter-relations) appears to be the greatest cause of death.
6. There are serious problems with the dissemination of services, knowledge and products.
 - (a) Veterinarians are not available in areas that need their services.
 - (b) Government veterinary schemes for the most part have failed because of lack of infrastructure, transport, supplies and, last but not least, reasons to incite innate initiative and drive in government veterinarians. In short, there is no reward system.
 - (c) No veterinary extension training exists in most countries. General extension agents or agricultural demonstrators (A.D.'s) are expected to be "masters of all knowledge" and are overloaded with inappropriate and unnecessary paperwork, most of which is not connected with education. In addition, most A.D.'s are not sufficiently educated themselves to carry out the expectations of the job.
 - (d) Animal health supplies are either in short supply or totally lacking due primarily to constraints in production ability within the country, inadequate distribution channels or a lack of foreign exchange.

- (e) Government sponsored external parasite control programmes are often inappropriate or non-functional. Examples are dipping vats or spraying programmes which fail, usually because of lack of chemicals or disinterest on the part of employees to keep the vats charged or get out and do the job. In addition to ticks in livestock of all ages, lice and fleas can be a very severe problem for neonates and young animals up to weaning age. These external parasites are totally ignored throughout most of the developing world.
 - (f) Internal parasite control programmes are sporadic, have not been correlated with strategic periods to best control parasites, and often based on the notion that all animals in tropical areas are full of parasites. No consideration has been given to grazing programmes, soil types, rainfall amounts or seasons. As a result, these programmes are expensive and not very effective.
7. Sustainability and environmental concerns are totally lacking. There is virtually no research into either area in the third world. It is difficult to get people interested in these areas of research primarily, in the author's opinion, because the rest of the scientific world does not hold this type of research highly, especially in the areas of the animal sciences.
 8. In an effort to spend donor funds, often developing countries pay no attention to any of the above-mentioned problems. The donor countries do not insist on any controls, economy, sustainability or environmental protection as long as funds have been spent and a good report written to salve the feelings of the people back home, who can then feel something is being done to help the less fortunate.
 9. Unfortunately, although animal health programmes sometimes succeed, a failing is that the owner of the animals simply expands the herd in expectation of a future crash in population. There are no grazing limits on tribal or common areas, or incentives to market excess animals, neither is there information and guidance on range and pasture conservation. The author is not aware of any country, even in Africa, where fodder harvest and storage for the dry season is traditional. During times of drought food and feed are distributed which keeps people and animals alive, thus further populating the area, and shortening the periods between devastation. Animal population control programmes are not traditional or customary and governments refuse to do anything about it. Birth control for the people is considered taboo and not spoken of, so the rest of the world talks about the African population increasing by 4 % per year and the population doubling every 20 years, and not one African in 1,000, including the well educated and the country leaders, knows what that population expansion entails or has any concern for it. Some donor will always step in and help when things get serious enough. Western nations continue to pour billions of dollars into aid and subsistence into countries whose "president for life" and most of its ministers are listed among the wealthiest people in the world.

RECOMMENDATIONS

- A. Research should involve exposing the real problems of the third world livestock economy.
 - 1. What are the real disease problems at the village level?
 - 2. How can we help the small producer in rural areas to keep his livestock alive, and make the operation sustainable and profitable?
 - 3. Look at strategic internal and external parasite control within areas of each country, not just the country or continent as previously.
 - 4. Conduct all research in a manner that will support a sustainable approach.
 - 5. All therapeutic regimens should be evaluated from an environmental aspect.
- B. Expand availability of privatized clinical veterinary services.
 - 1. Encourage private practice with subsidized pay for governmental work rather than government sponsored veterinarians.
 - 2. Encourage the government to be concerned with, and support, large scale, nation-wide disease control or eradication programmes and support private practitioners by using the latter rather than government employees in these programmes. The governments should also not be involved in the day to day practice of veterinary medicine.
 - 3. If subsidization is required, veterinary medicine rather than animal health products should be subsidized. A more usable and dependable distribution system is required in most countries. This type of programme will probably be less expensive and more productive in the long-term and reach the right people. Programmes such as this have worked in the western world over the last 50 or 75 years. They should also work in the developing countries.
- C. Develop educational programmes for rural livestock owners.
 - 1. Either expand extension services to the point where they can, in fact, teach and demonstrate to the farmer, and relieve them from any excess responsibilities, i.e. paper-work or other non-educational duties.
 - 2. Develop a livestock production extension team made up of professionals from all areas including animal production, breeding, management, marketing, nutrition, fodder production and handling, and veterinary medicine. The team does not necessarily need to consist of terminal degree holders, and probably all that is needed is a Bachelor or professional degree where appropriate. Train them to be teachers and put them into the field to teach village leaders or extension personnel. Allow them enough latitude to demonstrate what they

know so a change in behaviour will occur in that village or district. See that they are paid a livable wage and have supplies and technical assistance always available. This is not a short-term solution. It will take time and money, however, it is expected that the programme may last after the departure of the experts.

3. Develop programmes that explain the value of keeping fewer, more productive, animals and the techniques to make this sustainable, such as fodder production and storage, marketing of excess animals as early as possible, value of sale and/or barter and trade, what money can do and methods of investing excesses to increase production or quality of life. Investment to maintain sustainability is also a realistic goal.

RECOMMENDED INDIVIDUAL EDUCATIONAL PROGRAMMES

1. Feed production, harvest, storage and utilization.
2. Very simple feeds and feeding courses.
3. Management of pregnant animals throughout pregnancy, the birth process and nursing period.
 - (a) Nutritional needs.
 - (b) Comfort and protection of the dam.
 - (c) The birth process.
 - (d) Care of the newborn, including need for protection, comfort, colostrum feeding, as well as nutritional needs until weaning. Explain what FPT is and how it affects the newborn.
4. Feeding of animals for slaughter.
5. Marketing - both locally and to central markets.
6. Internal and external parasite control programmes that are strategic, sustainable, and environmentally sound.
7. Immunization programmes that are necessary and economical.
8. Pasture management and rotation programmes that are economical, sustainable and environmentally sound.
9. Programmes to teach the farmer how to recognize disease in the early stages, what action he can take and what he will need help for, if this is available.

10. Programmes that will increase productivity to the breeding herd, such as selection of suitable sires and evaluation of their breeding potential.

In closing, the author would like to repeat something he has told many farmers, professionals and interested parties alike. Traditions and customs are valuable human interests and should be preserved, however, if clung to without reason they make a very thin soup. The author truly believes this and encourages all to consider it.

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FOOD LOSSES DUE TO TOXICOSES AND PROGRAMME FOR THEIR REDUCTION

by

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INTRODUCTION

Food losses due to toxicoses constitute a serious health problem in animals and poultry. Some toxins are even capable of causing food loss directly at the field level or through contamination by environmental pollutants, industrial wastes, through spray or use of agrochemicals or by different types of mycotoxins and through toxic plants and many other chemicals and drugs.

The toxigenic fungi, although worldwide in distribution, are of special significance for developing countries where natural climatic conditions and unsatisfactory pre- and post-harvest practices favour mould growth and, in turn, promote elaboration of toxins. Some of the toxigenic fungi are responsible for the production of toxic metabolites and are associated with several disease conditions, e.g. sweet clover poisoning, lupinosis, fescue poisoning, romulea poisoning, infertility problems due to estrogen (coumesterol) containing lucerne (*Medicago sativa*), Deg Nala disease, and others (Gupta and Salunkle, 1985).

Several incidences of other types of toxicoses are also recorded every year in farm animals the world over and enormous production and reproduction losses and mortality are suffered by the animal and poultry industries. Some of the economic losses might result from impaired immunity or impaired liver and kidney function, decreased production, poor growth, lowered efficiency of feed conversion and increased mortality in livestock but so far no systematic survey is available either in India or in other developing countries to quantify the losses due to toxicosis.

In view of this, there is urgent need to develop a strategy to reduce food losses due to toxicoses and to develop a programme for their reduction.

I. FOOD LOSSES DUE TO MYCOTOXICOSES

A. Introduction

Mycotoxins are the substances produced by moulds as secondary metabolites which are toxic to animals and man. Nearly all toxigenic species of fungi are cosmopolitan and feeds become contaminated with them during various agricultural operations, storage, handling, etc., and under appropriate conditions of climate (temperature and humidity) and nutrients of substrate feeds on which they grow and elaborate their toxins. Toxigenic species of fungi

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causing natural mycotoxicoses and producing toxic metabolites have been identified, their toxic metabolites isolated, characterized, toxicologically studied and the toxicoses recognized during the last 25 years only. Mankind and his livestock, however, have been the victims of mycotoxins throughout the ages. Perhaps the oldest known example is ergotism, known as "St. Anthony's fire", which afflicted thousands of people in Europe. It was not until the 1600's that the discoloured grain was recognized as the cause of the disease (Hayes, 1980). The disease continued to occur well into the 19th century in Europe and America and was last recorded in 1943-44 in Russia due to the consumption of mouldy cereals (Joffe, 1971). Acute cardiac beriberi outbreaks in 1952 and 1955 in Tokyo, and in 1971 in Korea were strongly suspected to be related to the use of mouldy rice. Alimentary Toxic Aleukia (ATA) that occurred in the Soviet Union during World War II, was caused by over wintered grain infected with *Fusaria* species. Balkan nephropathy, an endemic disease affecting people in Yugoslavia, Romania and Bulgaria, was recognized to be caused by ochratoxin A.

Mycotoxins began to receive much attention only after 1960 when the outbreak of "Turkey X Disease" took toll of over 100,000 birds in the UK. The cause of the disease was found to be a toxic substance produced by the fungus *Aspergillus flavus* in ground nuts which was subsequently named as aflatoxin. The identification of this toxin stimulated further research leading to the discovery of many other mycotoxins whose synthesis, natural occurrence and toxic properties have been fully documented (Wyllie and Morehouse, 1977).

B. Toxicogenic Moulds and their Metabolites

In cereals and animal foodstuffs the mycotoxins most frequently found are produced by the *Fusaria*, *Aspergilli* and *Penicillia* fungi (Table 1) (Singh, 1982; Singh and Gupta, 1983; Gupta and Singh, 1985). *Fusarium* spp. are common plant saprophytes and pathogens. They occasionally grow on stored cereals having a high moisture content. In contrast the *Aspergilli* and *Penicillia* are not phytopathogens, but are primarily responsible for the post harvest deterioration of cereals due to their being able to grow at lower water activity than the *Fusaria* (Buckle, 1983).

Table 1. Natural Occurrence of Toxicogenic Fungi, their Mycotoxins and Substrate Feed Commodities

Mycotoxin	Toxicogenic fungus	Substrate feed commodity
Aflatoxins (B ₁ , B ₂ , G ₁ , G ₂ , M ₁ , M ₂)	<i>Aspergillus flavus</i> , <i>A. parasiticus</i>	Ground nuts and products, rice, maize, sorghum, cotton seed, rye, barley, wheat, coconut, other nuts, milk
Zearalenone (F-2 toxin)	<i>Fusarium roseum</i> , <i>F. triculatum</i> , <i>F. nivale</i> , <i>F. moniliforme</i> , <i>F. oxysporium</i> , <i>F. graminearum</i>	Maize, sorghum, barley, wheat, feed, hay
Trichothecenes (T-2 Toxin, nivalinol, deoxynivalinol, diacetoxyscirpenol)	<i>Fusarium</i> sp., <i>Myrothecium</i> spp., <i>Trichoderma</i> spp., <i>Stachybotrys</i> spp.	Maize, barley

Mycotoxin	Toxigenic fungus	Substrate feed commodity
Ergot toxins - Ergometrine group - Ergobasine, ergotamine - Ergocornine, ergokryptine - Ergoclavine group	<i>Claviceps purpurea</i> , <i>C. fusiformis</i> , <i>Aspergillus</i> spp., <i>Penicillium</i> spp.	Ergots, ergot infected pasture grass
Ochratoxins (A, B, C)	<i>A. ochraceus</i> , <i>Penicillium veridictum</i>	Cereals such as wheat, oats, rice
Tenuazonic acid	<i>A. tenuis</i> , <i>A. tamaritii</i> , <i>Sphaeropsis</i> sp., <i>Pyricularia oryzae</i> , <i>Phoma sorghina</i>	Diseased rice plants
P.R. Toxin	<i>Penicillium roqueforti</i>	Silage
Kojic acid	<i>A. flavus</i> , <i>A. oryzae</i>	Mouldy maize (corn)
Luteoskyrin	<i>P. islandicum</i>	Rice
ATA toxin	<i>F. sporotrichioides</i>	Oats, wheat, barley
Coumesterol (oestrogen)	<i>Pseudopezzia medicaginis</i>	Lucerne fodder
Trimogens (cyclopiazonic acid, Cyclopiazamic acid)	<i>A. flavus</i> , <i>A. fumigatus</i> , <i>P. patilans</i> , <i>P. cyclopium</i>	Feedstuff
Patulin	<i>A. clavatus</i> , <i>P. patulum</i>	Apples, rice, feeds, silage
Sterigmatocystin	<i>A. versicolor</i> , <i>A. nidulatus</i> , <i>A. luteus</i> , <i>A. ruber</i> , <i>A. flavus</i>	Cereals such as wheat, rice, peanuts
Penicillic acid	<i>Aspergillus</i> spp., <i>Penicillium</i> spp.	Maize, beans
Rubratoxin (A,B)	<i>P. rubrum</i>	Maize
Citrinin	<i>Aspergillus</i> spp., <i>Penicillium citrinin</i> , <i>P. veridictum</i>	Wheat, barley, peanuts, rice
Sporidesmin	<i>Phthomyces chartarum</i> , <i>Phomopsis rossiana</i>	0.1% in spores on dead pasture grass
Stachybotrys toxin	<i>Stachybotrys atra</i> , <i>S. alternans</i>	Hay and straw
Lupines	<i>Phomopsis rossiana</i>	Dried fodder, grains
Chetomin	<i>M. verrucaria</i> , <i>Chaetomium</i> spp.	Pasture grass, ryestraw
Alternariol, alternariol monomethyl ether	<i>Alternaria tenuis</i> , <i>A. dauci</i>	Weathered grain, sorghum

The *Fusaria* produce two classes of mycotoxins, namely zearalenone together with its derivatives and the trichothecenes. Zearalenone has oestrogenic properties producing hyper-oestrogenism in pigs (Culvenor, 1974). The trichothecenes, which include T-2 toxins and diacetoxiscirpenol, are produced by several *Fusarium* spp. Haemorrhagic syndrome in cattle culminating in severe losses has been associated with the feeding of brewer's grain containing T-2 toxin.

The *Aspergilli* and *Penicillia* produce a variety of mycotoxins including aflatoxin, sterigmatocystin, ochratoxin A, citrinin and patulin. Sterigmatocystin is probably a precursor for aflatoxin (Buckle, *loc. cit.*). Ochratoxin A and citrinin are nephrotoxic in pigs and are responsible for ochratoxicosis, bovine abortion and other syndromes in swine, birds and cattle. Patulin has been associated with the outbreaks of bovine hyperkeratosis in the USA (Culvenor, *loc. cit.*).

Several other toxigenic fungi are responsible for the production of toxic metabolites and may be associated with several disease conditions, e.g. sweet clover poisoning, lupinosis, fescue poisoning, romulea poisoning, infertility problems due to the oestrogen (coumestrol) containing lucerne (*Medicago sativa*), Deg Nala disease and others (Tables 2 and 3) (Shreeve *et al.*, 1983; Pier *et al.*, 1980).

Table 2. Diseases suspected as Mycotoxicoses^{1/}

Disease	Affected Animal	Major Effect
Rye grass staggers	Sheep, cattle	Ataxia
Bermuda grass staggers	Cattle	Ataxia
Myrotheciotoxicosis	Sheep, cattle	Depression, enteritis, salivation
Fescue foot	Cattle	Necrosis of fetlock
Deg Nala Disease	Water buffalo	Necrosis of extremities

^{1/} From Pier, 1981

Table 3. Mycotoxins Not Yet Definitely Associated With Field Disease^{2/}

Mycotoxin	Experimental effects
Alternaria toxin	Depression, fatal death, hemorrhage weakness, paralysis
Citreoviridin	Weakness, paralysis
Cyclopiazonic acid	Hepatic, renal and pancreatic necrosis
Islanditoxin (cyclochlorotin)	Periportal hepatic necrosis
Luteoskyrin	Centrilobular hepatic necrosis, carcinogenic
Patulin	Convulsions, edema, hemorrhage, teratogenic
Rubratoxin	Hepatitis, coagulopathy, teratogenic
Sterigmatocystin	Hepatic and renal necrosis, teratogenic

^{2/} From Pier, 1981

C. Natural Occurrence of Mycotoxins in Feeds

Natural occurrence of mycotoxins in cereals has been widely reported (Anon., 1979; Dalvi, 1986). In a survey for the contamination of cereals and soybeans with aflatoxin, overall 2.6% of maize samples were positive (ranging from 3-25 ppb). The incidence of aflatoxin in soybeans, wheat, oat and sorghum was 0.23, 0.38, 0.99 and 1.13% respectively. Three other surveys made in 1967, 1968 and 1973 for zearalenone in maize indicated that 0.7, 1.7 and 17% of the samples were positive and the concentration ranged from 400 to 5000 ppb (Table 4) (Buckle, *loc. cit*).

Table 4. Surveys for the Incidence of Mycotoxins in Contaminated Plant Products

Commodity	Number Examined	% Positive	Concentration (p.p.b)	Year
<u>Aflatoxins</u>				
Wheat	531	0.38	B ₁ 7 G ₁ 2	1964
Oats	304	0.99	6	1964
Grain sorghum	533	1.13	3-19	1964
Maize	1311	2.70	3-19	1964, 1965
Soya bean	866	0.23	7-10	1964, 1965
Maize	283	2.12	12-25	1967
Maize	293	2.73	6-25	1968
<u>Zearalenone</u>				
Maize	283	0.71	800-1250	1967
Maize	293	1.71	450-750	1968
Maize	223	17.0	100-5000	1973
<u>Ochratoxin A</u>				
Maize	283	0.35	110-150	1967
Maize	293	1.02	83-166	1968
Barley and oats	84	8.00	16-409.5	1972
Barley	269	6.30	14 trace	1976

Surveys for ochratoxin A in cereals have been made in North America and Sweden (Table 4). Maize and barley samples indicated the presence of 1.02% and 8% positive samples in USA and Sweden (Buckle *loc. cit*). Contamination of plant products has, however, been reported in surveys from various other countries (Tables 5 and 6) (Hayes, *loc. cit*).

There have been worldwide reports regarding the survey of mycotoxins in animal feedstuffs (Connole, *et al.*, 1981; Bryden *et al.*, 1980; Stoloff, 1977; Hesseltine, 1974; Mirocha and Christensen, 1974; Shotwell *et al.*, 1970, 1971; Shotwell, 1979). A study carried out in Canada during 1972-77 on 2,022 samples indicated that zearalenone was most frequently encountered and in 8% of the samples it ranged from less than 10 to over 100,000

ppb. In a study conducted on 523 samples of cereals, predominantly barley, in England and Wales, it was found that the 12.8% samples positive for ochratoxin were usually associated with inadequate drying or poor storage facilities. Sterigmatocystin, citrinin and zearalenone along with multiple contamination were also detected. A total of 811 compound feedstuffs (including imported commodities as ground nut, palm kernels, cottonseed, copra and soya wherein any mycotoxin present will contaminate the final compound incorporating them) were examined during 1976-1979. Aflatoxin B₁ was present in 4.8% of the samples (ranging 710 to 750 ppb) (Buckle, *loc. cit.*).

Although fungal contamination invariably leads to mycotoxin production, yet the presence of mould in feed is not sufficient for diagnosis of mycotoxin poisoning or for contamination of feed. The reverse is also true where many mycotoxins, being extremely stable, may be present even when the evidence of mould growth has disappeared as is seen in the case of pelleted feed. A survey conducted on 157 hay samples in England (Buckle, *loc. cit.*) revealed that although mould spoilage had occurred in most samples, only one sample was found positive with 40 ppb of sterigmatocystin, and similarly out of 457 samples of grass silage examined, patulin was detected in nine different clumps only, probably on the above analogy alone that optimum conditions for mould growth may not be suitable for toxin production.

D. Magnitude of Natural Contamination of Animal Feeds in India

In India, no systematic survey has been made with regard to the level of contamination of animal feedstuffs due to mycotoxins. However, in a study conducted during the period 1965-67, 82% of the ground nut cake samples from the states of Gujarat, Andhra Pradesh and Tamil Nadu were found contaminated (Table 7) (Anon., 1976). Nearly 50% of the ground nut samples from the West Indian Coast contained fairly high levels of aflatoxin (Wagle, 1970). In another survey made at Tamil Nadu, of the 134 samples of ground cake analysed, 28 were positive for aflatoxins. Similarly, the presence of aflatoxins has been shown in 4 out of 83 samples of gingely and 3 out of 96 of coconut oil cake. Besides these, 7 of the animal feeds, 7 of the poultry feeds and 4 of the oil cake mixtures (out of a total number of 38, 160 and 10 samples analysed respectively) were found to be positive for aflatoxin (Table 8) (Neelakantan, 1980). Screening of ground nut oil cakes sold in markets of Hapur (U.P.) revealed 70% contamination with high levels of aflatoxins (1135-2250 ppb) (Rampal *et al.*, 1976). The majority of ground nut cake and maize samples analysed at Hessarghatta revealed aflatoxin up to a level of 7.47 ppm (Singh, 1982). Another survey made in Andhra Pradesh by Jagdish Kumar and Gowda, (1979) on maize, wheat, poultry feed etc., yielded aflatoxins in the range of 0.03 - 1.75 ppm. An extensive survey was made by Singh and Sastry (1978-80) on various animal feed ingredients received with the reports of mortality or suspected morbidity, lowered production, etc. from various parts of the country, where 68% of the ground nut cake, 43% of poultry feeds, 54% of cattle feeds and 75% of the pig feed samples have been found positive for aflatoxins (ranging 0.05 to 2.0 ppm) (Table 9). Contaminated ground nut cake had been contaminating the compound feed samples (Gupta and Singh, *loc. cit.*). Reporting the incidence of aflatoxin B₁, Balasubramaniam (1985) observed that 66 of the various animal feed samples examined in Tamil Nadu were positive for aflatoxin B₁ and that ground nut oil cake samples were contaminated with a concentration ranging 0.33 to 26.7 ppm of aflatoxin B₁. Of the 35 poultry feed samples collected from organized farms in Haryana 23 were found positive for

aflatoxins B₁, B₂, G₁, G₂ (Paul Gupta *et al.*, 1985). Another survey on poultry feeds and ingredients revealed that 62% of the ground nut cake and 50% of the maize samples were positive for 0.3 and 0.2 ppm respectively (Johri *et al.*, 1987). Sudhakara Reddy *et al.*, (1984) and Patel *et al.*, (1981) also reported the level of contamination of some oil cakes and feeds due to aflatoxin. An exhaustive survey is required to be conducted keeping in view the regional temperature and moisture conditions and the agricultural practices to get some conclusive information and plan strategies to contain the hazards of mycotoxins in the country.

Table 5. Incidence of Aflatoxin Contamination in Feed Grains of Various Countries of the World^{1/}

Country	Commodity	No. of samples analyzed	% of samples positive	Contamination (ug/kg)	
				Range	Highest
Philippines	Maize	675	77%	0-1331	-
Thailand	Maize	62	35%	400	2730
Uganda	Maize	49	45%	400-1000	-
	Sorghum	69	26%	100-1000	-
Colombia	Sorghum	-	all	20	-
USA	Sorghum	599	2%	13-50	-
USA Midwest	Maize	293	8%	20	43
USA South East	Maize	60	21%	66	348
Central America	Dairy feedstuff	25	19%	30-70	320
	Poultry feedstuff	50	13%	30-60	194
	Sorghum	15	2%	100-200	-

^{1/} Singh and Gupta, 1983

Table 6. Incidence of Ochrotoxin A Contamination in Plant Products of Different Countries of the World^{1/}

Country	Commodity	Contamination	Contamination Range (ug/kg)
Canada	Wheat, oat, barley, rye (feed)	56.3	30 - 27,000
Denmark	Barley, oats	57.6	28 - 27,500
Denmark	Malt barley	6.0	9 - 189
France	Maize	2.6	15 - 200
Poland	Barley, wheat, oat, rye, maize		50-200

Country	Commodity	Contamination	Contamination Range (ug/kg)
Poland	Mixed feed	4.9	10-50
Sweden	Barley, oats (feed)	8.3	16-405
Yugoslavia	Maize, wheat, barley	12.8	5-90
USA	Barley	14.8	10-40
USA	Maize	0.4	10-150
USA	Maize	1.0	5-115
USA	Wheat (red winter)	1.0	5-115
USA	Wheat (red spring)	2.0	5-115

7 From Hayes, 1980

Table 7. Surveys Made on Aflatoxin Contamination in India

% Contamination	Regions	References
82	A.P., T.N., GUJ	(Neelakantan, 1965-67, 1980)
50	M.P.	(ICAR, Jabalpur, 1967, Anonymous, 1976)
70	U.P.	(Rampal <i>et al.</i> , 1976)
50	West Coast	(Wagle, 1970)
747 ppm	Hessarghatta	(Singh, 1982)

Table 8. Mycotoxins in Various Food and Feeds in T.N. Region

Mycotoxin	Sample	No. analyzed	No. positive
Aflatoxin	Cotton seed	30	2
	Ground Nut Cake	134	28
	Gingely oil	83	4
	Cake coconut oil	96	3
	Cake poultry feed	160	7
	Dried vegetables	43	4
	Dried dates	18	1
	Areca nut and Supari	147	21
	Dried coconut	6	1
Patulin	Supari	67	1
Penicilic acid	Apple	6	1
Sterigmatocystin	Wheat, rice, cottonseed	940	20

Table 9. Percentage of Contamination of Animal Feeds with Aflatoxin, Izatnagar (1972-80)^{1/}

Feed	No. Analyzed	No. Positive	% Positive
Ground Nut Cake	74	51	68
Poultry feed	16	7	43
Cattle feed	35	19	54
Pig feed	12	9	75
Others ^{2/}	353	85	24

^{1/} Sastry and Singh, 1978-80.

^{2/} Hay and other feed ingredients as barley, maize, wheat, bran, rice, bran, etc.

E. Biological Effects of Mycotoxins

The effects of aflatoxins vary considerably from species to species and are not always predictable on the basis of present knowledge derived from animal models or from structural activity relationships. In higher animals their actions are affected by sex, strains, environmental factors, nutritional status and interactions with other chemicals (Hayes, *loc. cit.*).

Mycotoxins cause inhibition of the enzymes of the Kreb's cycle and the respiratory chain. They also inhibit the oxidative phosphorylation by first affecting glycogen metabolism. A variety of other biological functions including carbohydrate and lipid metabolism are also affected by them. Reduction of hepatic glycogen levels has been observed most often after exposure to a mycotoxin including aflatoxin B₁, ochratoxin A, rubratoxin B, penitrem A and citrinin. Lipid metabolism appears to be affected to a greater extent by mycotoxins than the carbohydrate metabolism. Several mycotoxins including aflatoxin B₁, ochratoxin A, luteoskyrin, citrinin, penitrem A, rubratoxin B and T-2 toxin cause accumulation of hepatic lipids. They have also been observed to affect the nucleic acid and protein synthesis by inhibiting the RNA polymerase. The trichothecenes contain the most potent small molecule inhibitors of protein synthesis. Patulin, PR toxin and sterigmatocystin inhibit nucleic acid and protein synthesis (Hayes, *loc. cit.*, Patterson, 1976).

The biological effects can be categorized as acute as well as chronic, and include liver damage and nephrotoxic, cytotoxic, dermatotoxic, neutrotoxic, immunosuppressive, mutagenic, carcinogenic and teratogenic effects.

Although several mycotoxins caused hepatic damage, aflatoxin B₁ is the most potent hepatotoxin and the liver has been found to be the target organ (Butler, 1964). Acute hepatocellular necrosis appears to result from the action of aflatoxins at a number of intercellular sites. There are other mycotoxins which induce hepatic damage, such as rubratoxin B, sporodesmin and citrinin, that may have economic importance because of their tentative association with mycotoxicoses in farm animals.

Although mycotoxins cause lesions in a target organ, damage to other organs and tissues also occurs. Rubratoxin B causes hepatic damage and also induces renal lesions as do aflatoxin B₁ and sterigmatocystin. Citrinin and ochratoxin A are the best understood nephrotoxins (Austwick, 1983).

A group of tetracyclic sesquiterpene mycotoxins, the trichothecenes, induce dermal lesions, including skin irritation, haemorrhage and desquamation, if applied to skin. In addition, these mycotoxins have antibiotic, cytotoxic and neurotoxic (emetic) effects. Diacetoxyscirpenol (DAS) and T-2 toxins are the best known compounds in this group.

Butenolide and the photosensitizing furocoumarins are other examples of dermatotoxic mycotoxins. Ergot alkaloids affect, among other things, smooth muscle, and muscarine, one of the mushroom poisons, acts on the post-ganglionic parasympathetic synapses. In addition to causing excessive salivation in farm animals, slaframine acts in a fashion similar to acetylcholine. Penitrem A induces tremors, convulsions and death in experimental animals, and has been involved in many fatal neurologic outbreaks in sheep, horses and cattle. Citreoviridin and patulin have also been implicated in affecting the nervous system. Citreoviridin causes paralysis and convulsions with subsequent respiratory and cardiac failure leading eventually to death (Hayes, *loc. cit.*). Table 10 depicts associations of mycotoxicosis with acute primary diseases of livestock and poultry.

Table 10. Mycotoxicosis Associated with Acute Primary Diseases of Livestock and Poultry^{1/}

Mycotoxicosis	Animal species	Primary syndrome
Aflatoxicosis	Poultry, swine, cattle, dog, horse	Acute hepatitis, haemorrhagic disease, death
Ergotism	Cattle, sheep, chickens, swine	Gangrenous necrosis, nervous seizures, reproductive failure
Facial eczema	Sheep, cattle	Cholangiohepatitis, photosensitivity
Fuzariotoxicoes Vomitoxicoes T-2 toxicosis Diacetoxyscirpenol	Swine Swine, cattle, poultry- Swine	Enteritis, emesis Dermonecrosis, gastroenteritis Oral, gastroenteric necrosis, haemorrhage
Leucoencephalomalacia Zearalenone toxicosis	Horses Swine	Nervous depression, incoordination Estrogenism
Lupinosis	Sheep	Hepatic necrosis, oedema
Ochratoxicosis	Swine, turkey, chicken	Nephropathy
Citrinin toxicosis	Swine, cattle	Nephropathy
Paapulum staggers	Cattle, sheep, horses	Ataxia
Penitrem intoxication	Cattle, sheep, dog	Fasciculation, ataxia, prostration
Slaframine toxicosis	Cattle, sheep	Salivation, diarrhoea, polyuria
Stachybotryotoxicosis	Horses	Dermonecrosis, gastroenteritis, haematopoietic depressions

^{1/} From Pier *et al.*, 1980

In normal chickens the immunological mechanism is dependent on the bursa of Fabricius for humoral mediated immunity and on thymus for cellular mediated immunity. Any damage to the cellular integrity of these organs by physical, chemical or biological agents results into impairment of immunity. A drastic reduction in the sizes of these two organs has been shown in birds consuming aflatoxin containing diets. Even concentrations of aflatoxins that do not inhibit growth can reduce the size of these organs. Regression in these organs leads to poor production of cell mediated and humoral mediated immunity. Impaired phagocytosis has also been noted due to the inhibitory effect of aflatoxins on the reticulo-endothelial system. Depression in IgM occurred in swine from field outbreaks of aflatoxicosis (Pier, 1981). Some of the agents such as Marek's disease virus, ALC virus and gumboro disease (IBD) virus are themselves immunosuppressive. Thus the immunosuppressive effects of aflatoxins and of infectious agents add up and the combined effect is expressed in a more severe form of disease. Other infectious agents which are not immunosuppressive may also express in a more observable way under the influence of aflatoxins (Thaxton, *et al.*, 1974; Giambone, *et al.*, 1978).

Aflatoxin B₁ has been studied for its mutagenic potential on bacterial and animal cells. It is found to cause chromosomal aberrations and DNA breakage in plant and animal cells. Mitotic inhibition caused by aflatoxin B₁ might be due to its binding covalently with DNA. Similarly, microsomal activation is also an absolute requirement for mutagenicity (Anon., 1979). Mutagenic and carcinogenic properties depend upon the metabolic activation of a DNA alkylating agent, presumably the 2,3-epoxide now generally accepted to be a bacterial mutagen and proximal carcinogen (Ong, 1975; Patterson, 1977 and 1983). Exposure to aflatoxins during organogenesis results in malformations incompatible with life. Hamsters are highly susceptible to teratogenic effects of aflatoxins resulting in malformed, dead or reabsorbed fetuses, whereas in chicken the major malformation observed is in limbs (Elis and DiPaolo, 1967; Schoental, 1983). Toxicology of mycotoxins is reviewed by Ueno (1985) and oestrogenic metabolites discussed by Hacking (1983).

F. Incidence of Mycotoxicoses

Many incidences of mycotoxicoses are recorded every year in farm animals the world over and enormous production and reproduction losses and mortality are suffered by the animal industry. The occurrence of mycotoxicoses under natural conditions in animals may be either by feeding on mouldy grain and legumes, mouldy hay or standing pastures containing mycotoxins. Few incidences reported in some countries are listed in Table 11. It is likely that in India such incidences have occurred in the past, but due to lack of records and a poor follow-up system, they went undetected. Isolated reports of the outbreak of aflatoxicosis are available, such as the one in ducklings at Hosur farm (Damodaran, 1974) and at a poultry farm in Kerala (Pradhan, 1982). Aflatoxicosis in cattle was recorded by Sastry *et al.*, (1965) involving 24 Murrah buffaloes in Andhra Pradesh where aflatoxin contaminated ground nut cake was found to be the incriminating feed. Another outbreak of mycotoxicosis involving 126 crossbred cattle and leaving 58 dead was reported from Mysore state (Gopal *et al.*, 1968) and here too feed was found contaminated with 1.1 to 25 ppm of aflatoxin where ground nut cake had been the major feed component.

Table 11. Countries of Occurrence of Mycotoxicoeses and Type of Toxicity^{1/}

Mycotoxicoesis	Countries	Type of toxicity	
		Cytotoxic antimitotic	Neurotoxic
<u>Mouldy Corn</u>			
Aflatoxicosis	Africa, many others	+	(Others)
Alimentary toxic aleukia	USSR	+	
Genital hypertrophy	USA, Australia		
Pig mortality	USA	+	
Poultry haemorrhagic syndrome	USA	+	
Cattle mortality	USA	+	
<u>Mouldy Hay</u>			
Stachybotryotoxicosis	USSR, Eastern Europe	+	+
Bovine hyperkeratosis	USA	+	
Bovine abortion	USA	+	
Trembling syndrome	USA	+	
Sweet clover poisoning	USA	+	
<u>Standing Pastures</u>			
Ergotism	Europe, USA, Australia, New Zealand		+
Facial eczema	New Zealand, Australia	+	+
Lupinosis	Europe, Australia, South Africa		
Salivation syndrome	USA		
Fescue poisoning	Australia, New Zealand, USA		
Romulosis	Australia	+	
Maize poisoning	Australia	(?)	(+)

^{1/} From Culveoor, 1974

Aflatoxicosis in poultry was further reported by Gopal *et al.*, (1969). Mortality involving 4,000 rabbits in a private farm at Kulu valley has also been implicated with aflatoxin contaminated feed (Malhotra and Khanna, 1973).

In an incidence of aflatoxicosis in man and domestic dogs, more than 100 people were reported dead in Banswara district of Rajasthan and Panchmahal district of Gujarat. The disease (hepatitis) was identified as resulting from consumption of maize containing 6.5 to 15.6 ppm aflatoxin (Krishnamachari *et al.*, 1975). The possible role of aflatoxin in the etiology of Indian Childhood Cirrhosis has been evaluated by Amla *et al.*, (1971) and a positive correlation between aflatoxin content of food grain and the incidence of liver enlargement in children indicated by Srinivasamurthy, (1975). Similarly, some other reports are also available on aflatoxicosis in cattle, buffaloes, poultry and ducklings (Vaid *et al.*, 1981; Manickam *et al.*, 1985; Paul Gupta *et al.*, *loc. cit.*, Gopalkrishna Rao *et al.*, 1985). Reports of mortality in livestock due to the feeding of Matona Kodo in Mandla (M.P.) and of Deg Nala disease in Haryana and Punjab could be also attributed to mycotoxins.

II. FOOD LOSSES AND PRESENT STATUS OF PESTICIDE RESIDUES

INTRODUCTION

The term monitoring means a programme to measure residue in substrate, geographical region, set of species, or other systems with a definite set of boundaries (Witt, 1977). It is a well planned study and one can compare values obtained over a definite course of time. In India, unfortunately, systematic monitoring has never been done to evaluate the level of residues and their biological effects. Limited surveys have been carried out by P.A.U., Ludhiana; Indian Agricultural Research Institute, New Delhi; C.F.T.R.I., Mysore; Haryana Agricultural University, Hissar, etc. (Gupta, 1985). Some reviews and compilations (Bindra and Kalra, 1973; Agnihotrudu and Mithyantha, 1978; Edward *et al.*, 1978; Gupta, 1980; and Kalra and Chawla 1981 and 1983, Gupta, 1986) clearly bring out widespread occurrence of pesticide residues in food commodities and frequently much above the legally permitted level; consequently, the level of residue in animal tissues and human bodies is very high.

Many western countries have established intensive monitoring programmes to estimate the levels of pesticide residues in both abiotic and biotic components of the environment. Such a national programme to monitor pesticide residues and their biological effects is still lacking in India. In order to meet this objective, the ICAR has already initiated an All India Coordinated Programme on Pesticide Residues from food crops and vegetables but a systematic approach to monitor the residues in animal and human tissues is still lacking.

A. Migration of Pesticides

Although the migration of pesticides and their persistence in soil, air and water are important, this review is limited only to residues in human, animal and plant sources.

B. Pesticide Residues from Meat, Fish, Eggs and Feed

The analysis of samples of meat, milk and eggs collected from the organized farm at this Institute revealed the presence of DDT. There was a high level of DDT (0.528 ppm from Pantnagar) in milk as compared to samples collected from IVRI (0.39 ppm). Fat contained the highest level (7.2 ppm) of DDT as compared to other tissues.

Analysis of feed sample such as maize, wheat, gram, barley, oats, rice polish, ground nut cake and the conventional seed husks indicated that most of the samples contained DDT and the residue varied from 0.08 to 0.8 ppm. Similarly, 10 samples each of the major roughage, wheat bhoosa or green fodder such as maize, oats, barley, barseem, lucerne and cowpea on analysis contained residues ranging from 0-0.45 ppm. Most of the animal feeds and fodders invariably contained DDT at very low levels (Sastri and Singh, 1978).

Almost all the samples of meat, fish and eggs collected from U.P., Delhi, Andhra Pradesh and Punjab showed the occurrence of DDT and BHC residues but the residues were below the prescribed maximum residue limit.

The highest concentration of DDT in meat samples was 1.6 ppm (Sharma *et al.*, 1979). In most other samples of meat, the concentration was less than 1 ppm. The egg samples from Delhi, (Agnihotri *et al.*, 1974), Punjab (Kalra and Chawla, 1978) and U.P. (Tripathi, 1969) contained less than 1 ppm residues. However, Lakshminarayana (1980) has reported as high as 8.01 ppm DDT and 2.5 ppm BHC in egg samples collected from Hyderabad. He has also shown occurrence of other chlorinated insecticides such as lindane, heptachlor and endrin.

The results of analysis of milk samples from Delhi (Agnihotri *et al.*, 1974a; Kalra and Chawla, 1983), Hyderabad (Lakshminarayana, 1980), Bombay (Noronha, 1978) and Punjab (Sandhu, 1979; Dhaliwal and Kalra, 1977 and 1978; Kalra and Chawla, 1983) clearly showed widespread contamination of milk samples with DDT and BHC. Most of the samples analyzed showed residues of both DDT and BHC. The residues of other chlorinated insecticides have not been detected in any sample except from Bombay, where Noronha (1978) has reported 76 ppm dieldrin residues in 10 out of 24 samples collected from the local vendors. However, more samples need to be analyzed to confirm these results.

The residue of DDT in milk primarily existed in the form of p, p TDE or DDD, p, p DDT and p, p DDE. The percentage distribution was 64, 23 and 13 respectively (Kalra and Chawla, 1981). The BHC residue occurred primarily in the form of alpha and beta isomers, whilst the gamma and delta isomers were present in very small quantities. The percentage distribution of these isomers were 56, 36, 5 and 3 respectively.

The analysis of name brand baby foods also showed contamination with DDT residues at levels higher than the prescribed maximum residue limit of 1.25 ppm (Dhaliwal and Kalra, 1978).

The contamination was further studied in some popular brands and home made butter samples from different parts of the country. Most samples were found to be contaminated with either DDT or BHC or both. The level of DDT was invariably higher than the prescribed maximum residue limit ranging from 0.76 to 8.10 ppm. The level of BHC residues was also high ranging from 0.32 to 5.60 ppm. The ghee samples from Andhra Pradesh, Rajasthan, U.P. and Punjab were also found to be contaminated with DDT and BHC residues at levels much above the prescribed maximum residue limit (Sandhu, 1979).

C. Pesticide Residues in Human Beings

Most of the information available of residues in humans is on organochlorine insecticides such as DDT and BHC which are used extensively in agriculture as well as for human health programmes. These pesticides are easily detected because of the persistent nature and ease of analysis. Human adipose tissue, blood and milk have been analyzed for estimation of residue levels. The level of residue found in the human body can be used as an index of pesticide exposure, (Krishna Murti, 1984).

According to Dale *et al.*, (1965) adipose tissue of Indians from certain areas contained more than 20 ppm of total DDT which is the highest concentration found anywhere in the world. About 10 years later, Ramchandran *et al.*, (1974) also reported a very high concentration of DDT in the Delhi population, ranging from 0.17 to 99.35 ppm in males and 2.54 to 176.54 ppm in females.

Recently, Bhaskaran *et al.*, (1979) have shown a downward trend, the level of residues ranged from 2.0 to 10.10 ppm only. However, reports from Punjab, Calcutta, Bangalore, Bombay and Chandigarh have shown a much higher level of DDT residues in the Indian population (Agnihotri, 1983). Since the number of samples analyzed by Bhaskaran *et al.*, (1979) were very low, a true picture may not have emerged. DDT was the major metabolite which accounted for 50% or more of the total DDT.

In some cases, the presence of BHC was detected. The highest concentration of BHC in Ludhiana was 30.05 ppm; Bangalore, 94.54 ppm; and Chandigarh 11.03 ppm. The beta BHC was the major isomer which accumulated in the adipose tissue (Chawla *et al.*, 1978). Such a high level of BHC has not been reported from any part of the world except from Japan, Romania, Poland and Czechoslovakia (Wasserman *et al.*, 1975).

The level of DDT residues detected in India is much higher than that found in any other country of the world. In most countries of the world, DDT residues, including metabolites, in the human population were generally less than 10 ppm (Davies, 1973).

The residues were comparatively higher in Israel, 18.1 ppm; Italy 15.4 ppm; Spain 15.7 ppm; in USA 14.4 ppm. DDE was the major metabolite varying from 43.86% (Davies, 1973). So far no PCB's have been detected. Only traces of other organochlorine insecticides have been detected.

Since there is a direct relationship between the residues present in blood and those accumulated in adipose tissues, analysis of blood has been done for assessing the body burden of residues in the general population in different countries of the world. Davies (1973) reported DDT in almost all the samples tested but its concentration was less than 0.05 ppm. However, Aggarwal *et al.*, (1976) reported 0.005 - 8.40 ppm DDT residues in the male and 0.021 - 1.828 ppm residues in the female Indian population from Delhi. This is about 8 to 10 times higher than the values reported from other parts of the world.

Breast milk samples collected from Punjab contained a high level of DDT and BHC residues. The total DDT residues ranged from 1.4 to 102.2 ppm and that of BHC from 1.25 to 27.52 ppm in adipose tissue. Considering this data, suckling neonates are consuming several fold higher DDT than recommended by the World Health Organization (Kalra and Chawla, 1981).

D. Residues in Market Samples of Food Commodities

Market samples of vegetables have been analyzed for pesticide residues in Delhi (Agnihotri, *et al.*, 1974b), Hyderabad (Lakshminarayana and Krishna Menon, 1975), Mysore (Visweswariah and Jayaram, 1972), Punjab (Bindra and Kalra, 1973 and Gupta, 1979), Bombay (Noronha, 1978, and Khandekar, 1980) and Haryana (Verma, 1980).

In Delhi, 60 samples of eight vegetables were drawn from eight different markets and analyzed for residues of malathion and organochlorine insecticides. Most of the samples were found to contain either DDT or BHC or both. About 25% of the samples analyzed showed residues above the maximum residue limit prescribed by FAO/WHO (1975).

In Hyderabad, 128 samples of different vegetables and potato tubers were analyzed during the period 1969-79. About 60% of the samples were contaminated by either DDT or BHC, but only 12% of samples contained residues above the maximum residue limits. In general, the level of residues and incidence of contamination was less during the year 1978-79. Besides, BHC and DDT, residues of other chlorinated insecticides such as endrin, heptachlor and endosulfan were also detected.

In Hissar (Haryana), 195 samples of vegetables, including potato, were analyzed and only 59 were found to be contaminated, mostly with residues of BHC, endosulfan and DDT. In most cases, the residues were below the maximum residue level. Similarly, samples of vegetables from Punjab showed negligible residues of organochlorine insecticides.

However, all the 300 samples of leafy vegetables collected from Mysore were found to contain excessive residues of BHC. Potato samples contained residues ranging from 0.1 to 169 ppm. A high level of insecticides has also been reported in potato tubers from Bombay (ranging from 0.3 to 7.04 ppm). Besides DDT, residues of lindane, dieldrin and endrin have been reported in potato samples.

This data clearly show a high level of pesticide residues in samples collected from large metropolitan cities of India like Bombay, Delhi, etc. where vegetables fetch good prices. It seems that the cultivators are using pesticides recklessly and injudiciously without observing the safe waiting periods, otherwise the high residues reported from Delhi (Agnihotri *et al.*, 1974a, 1974b), Mysore (Majumdar, 1973) and Bombay (Noronha, 1978) are not possible. Recently, Agnihotri *et al.*, (1980) have reviewed almost 150 insecticide schedules conducted at IARI, New Delhi, on different crops including vegetables.

Among cereals, wheat has been surveyed mostly because of its predominance in the Indian diet. The studies conducted in Punjab (Bindra *et al.*, 1973; Chawla and Kalra, 1983), Haryana (Garg *et al.*, 1979), Delhi, Gupta, 1986 (ICAR Report, 1987) and Bombay (Noronha *et al.*, 1980) showed widespread contamination of wheat grain with residues of DDT and BHC. Residues of other chlorinated insecticides have been reported in rice from Bombay, (Noronha, *et al.*, 1980). The contamination of market samples of other cereals such as maize and rice is limited to some isolated samples only (Kalra and Chawla, 1983).

Like cereals, pulse samples collected from a market also showed the presence of excessive residues of both DDT and BHC. Analysis of pulse samples from U.P. showed very high residues of DDT and BHC. The levels of DDT varied from 10 to 175 ppm and BHC from 7 to 87 ppm. Similar results have been obtained in pulse samples from Hyderabad (Lakshminarayana, 1980) and Mysore (Majumdar, 1973). However, Kalra and Chawla (1978) have analyzed 10 samples from Punjab. They found a maximum of 1.02 ppm DDT and 0.05 ppm BHC in 8 samples contaminated with insecticide residues.

A high level of DDT and BHC residues detected in some of the wheat, pulse and rice samples could be the result of direct mixing of these insecticides during storage as concluded by the ICAR Special Committee on Harmful Effects of Pesticides. However, traces of a low level of residues detected from most of the wheat, pulse and other cereal samples could hardly afford any protection against storage pests and, therefore, the cause of contamination could be the contaminated soils on which these crops were raised. There is enough evidence

to show that plants growing in insecticide contaminated soil absorb and accumulate residues despite their non-systemic nature and poor solubility. Translocation of organochlorine insecticides have been shown in cereals, pulses and potato tubers. In addition, in villages, indoor spaces are heavily sprayed with BHC or DDT under the malaria eradication programme. The mud walls and roofs of these houses contain heavy deposits of these insecticides and when grains are stored in such places there is every possibility of their being contaminated. Residues of insecticides in spices viz. black pepper, celery seed, dill seed, turmeric, ginger and fennel exported from India have also been reported (Sullivan, 1980). In general, although all the spices were found to be contaminated with residues of DDT and BHC, the level was less than the tolerance limit. Besides DDT and BHC, traces of dieldrin and endrin were also detected in some of the samples. However, no PCBs were detected in any of the samples.

Analysis of oilseeds and oil have shown the presence of excessive residues of DDT and BHC. In Delhi, all the 15 samples of 5 oilseeds analyzed showed residue of DDT which varied from 1.1 to 4.1 ppm (Thakre, *et al.*, 1969). Three samples of cottonseed analyzed from Punjab showed 0.85 to 1.28 ppm DDT and 0.56 to 0.87 ppm BHC. The residues in oil samples collected from a Delhi market varied from 5.7 to 22.8 ppm in 1974. However, the level of residues was low in oil samples collected from Hyderabad and Punjab. In Hyderabad and Punjab 12 samples that were analyzed during 1978-79, the level of DDT varied from traces to 0.56 ppm. Similarly, analysis of 39 samples of soils showed widespread occurrence of BHC and DDT residues (Battu, *et al.*, 1980) but the mean level of DDT residues was 0.41 ppm and BHC 0.23 ppm. Similarly, analysis of 39 samples of soils showed widespread concentrate of BHC and DDT residues (Battu, *et al.*, 1980) but the mean level of DDT residue was 0.41 ppm and BHC in oil samples of India, no residues were detected in the 5 samples of a popular brand of vegetable oil (Battu, *et al.*, 1980).

E. Health Effects of Pesticides

On long term exposure pesticides are known to affect animals or humans in a variety of ways. To me it seems that the effect of pesticides on the immune system, their effect on reproduction, their ability to cause cancer both in animals and human beings, and their tendency to influence the liver microsomal enzyme system in animals and perhaps human beings, needs serious consideration. We must therefore take into account the problems relating to their long term effects on human beings, animals, wildlife, etc. For the purpose of discussion these effects have been categorized into immune toxicology, reproduction toxicity and teratogenicity, and mutagenicity and carcinogenicity. In addition, several pesticides are known to have cumulative effects when given simultaneously. These two aspects of pesticide toxicology are beyond the scope of this discussion and can be found elsewhere (Gupta, 1986).

(i) Pesticides and the immune system

The bulk of literature concerning the immune alterations, currently available through laboratory animal studies and from clinical reports suggests that an alteration of immune function is an important aspect of environmentally induced chemical toxicity. Surprisingly, the role of the immunologic system in response to pesticides has not been widely studied. However, in recent

years, there has been an increasing interest in the effects of pesticides reported to have immunologic effects, including DDT, dieldrin, carbaryl, carbofuran, methylparathion and endosulfan. The available data on immunosuppressive effects of many of these chemicals are inconclusive. A more detailed study of chronic effects from long term exposure to demonstrate effects of immunogenic responses is necessary in order to have a better understanding of the effects of these chemicals on the immune system.

(ii) Reproduction toxicity and teratogenicity

Several organochlorine pesticides have shown no evidence of teratogenicity. For example, DDT does not produce any teratogenic effect but DDT carrier women may show frequent abortions and complications during pregnancy and parturition. Similarly, experimental animals with aldrin and dieldrin at low dosage show normal reproduction but at higher dose levels, teratogenic and embryocidal effects have been reported. Another insecticide, chlordane, at a dose level of 100 ppm reduced the viability of first and second generation mice but no teratogenic effects have been reported. A high dose of methoxychlor may lead to testicular atrophy but concrete data on reproduction and teratogenicity is lacking. Endrin at a higher dose has been reported to produce some teratogenic effects in hamsters and mice but no such data on low dose level is available. After exposure of rats to endosulfan no teratogenic effects have been observed. However, there is some indication of alteration in biochemical parameters of testes in rats exposed to endosulfan.

Several other compounds such as carbaryl, captan, folpet, difolatan, organomercury, 2, 4, 5-T, pentachloronitrobenzene (PCNB), paraquat, thiriam, ziram, ethylenethiourea, ethylene and bis-dithiocarbamates, were reported to cause teratogenic effect at least in some mammalian species and at some testable dose levels. Carbaryl can reduce fertility, and at least in guinea pigs after daily oral doses during organogenesis. Ethylenethiourea can produce malformations in the central nervous system and skeletal systems of foetal rats dosed maternally with 10 to 80 mg/kg orally during gestation.

For the last few years, attention has been diverted to the teratogenic effects of 2, 4, 5-T and 2, 4-D for their possible effects on the human foetus and in other animal species. TCDD is a highly toxic compound and is a common contaminant of these herbicides. TCDD has been found to be teratogenic. Other compounds containing TCDD when given during gestation lead to varying degrees of teratogenic effects. Whether pure samples of 2, 4, 5-T and 2, 4-D can produce teratogenic effect is a controversial issue. Organomercury can cause serious neurological disorders in offspring from pregnant women exposed to this compound.

There seems to be no confirmed relationship between exposure to pesticides and human teratogenicity because most abnormalities reported with pesticides are at a higher dose level and with variable concentrations of by-products and impurities. The relationship of pesticide teratogenicity and human health is thus an important consideration for any conclusion drawn from such studies.

C. Mutagenicity and Carcinogenicity

Some pesticides are known to induce hepatic microsomal enzyme activity and thus affect the rate of steroid hormone production and metabolism. Due to this and other factors, great concern has been shown about mutagenic and carcinogenic effects of these compounds. International Agency for Research in Cancer (IARC) initiated a programme in 1971 to evaluate compounds for carcinogenicity. Based on available data it has been concluded that some compounds may produce tumours in experimental animals but may be associated with an increase in cancer in the human population. For example, DDT has been reported to cause hepatic cell tumours in rats but there has been no information which establishes that DDT causes hepatic cancer in human beings.

Recently, mirex has been shown to induce cancer and ethylenethiourea can cause hepatic tumours in mice. Ethylenethiourea also produces thyroid tumours in experimental animals and it is also mutagenic. Carbon tetrachloride (CCl_4) which is used as fumigant, has produced liver tumours in the mouse, hamster and rat following several routes of administration including inhalation and oral ingestion. Almost similar hepatomas have been reported in mice and rats after administration of high doses of amitrols. In view of this, IARC has evaluated several hundred pesticides for their mutagenic potential in animals and their association with cancer in the human population.

III. FOOD LOSSES DUE TO METALS AND INORGANIC SALTS

Metals and inorganic salts produce animal poisoning because of their wide distribution and use as agricultural chemicals. They are also prevalent as components of greases and oils used on farm machinery, portions of waste materials found in garbage disposed on animal pastures, their presence in plants and as feed additives, and the ever present possibility of their being present as a result of environmental pollution. In addition to their abundance, these compounds have the added hazard of being persistent in nature; hence their application to environmental areas and surfaces results in their being present for many years. Such problems have been demonstrated by attempts of employees to dispose of arsenic, lead, and mercury containing materials by burning or dumping on open ground. The introduction of livestock to such areas in later years has resulted in severe animal losses.

Fluorine-containing rocks and soils and fluorine contaminated water are well recognized sources of danger to livestock in many parts of the world; well water containing excess nitrate has caused fatal poisoning in both animals and humans. Minerals which are present in the soil in a form unavailable to animals are sometimes taken up and accumulated by plants. Examples are chronic copper poisoning or "toxaemic jaundice" in sheep from the accumulation of copper by non gramineous plants, molybdenosis or teart in cattle grazing soils high in molybdenum, and the accumulation of selenium by indicator plants, giving rise to various forms of selenium poisoning. The problems are manifestly local ones. Although the problems arising from metals and inorganic salts are many and multifold, very limited information on the extent of food losses due to metals and inorganic salts is available. For example, tin is present in small amounts in most animal and human tissues, it is uncertain whether it is an essential element for mammals. However, recent results indicate that tin is an essential nutrient for normal growth of the rat. Both inorganic and organotin compounds at concentrations similar to those present in feeds were found to stimulate growth rate in rats

maintained on purified amino acid diets. It has been concluded that tin, as an essential element, could have a function at the active site of some metal dependent enzymes; however, this has still to be confirmed.

Compared with most organotin derivatives, inorganic tin and its salts are not highly toxic, mainly because of their poor absorption and rapid tissue turnover. The systemic toxicity of some simple tin salts is difficult to assess because of the irritant properties of their solutions.

Distinction should be made between the effects of di, tri, and tetra-substituted organotin compounds. The principal toxicological difference is that some tri-substituted compounds have a specific effect on the central nervous system producing cerebral oedema, whereas, di-substituted compounds do not produce this effect but are potent irritants that can induce an inflammatory reaction in the bile duct. Toxicologically, the tetra-substituted compounds resemble tri-substituted compounds which are generally more toxic than the mono- and di-substituted derivatives. These compounds are known to produce a variety of toxic syndromes including immunosuppression.

IV. RADIOACTIVE MATERIALS

Animals may be exposed to radiation from external sources or from radioactive substances which, by intent or accident, have entered the body. Certain radioactive isotopes are among the most poisonous substances known, lethal doses being of the order of micrograms or less. Although external radiation does not constitute a poison in the accepted sense of the term, it is felt that this article should contain a brief account of it.

The sources of ionizing radiation may vary from the natural radioactive elements to those produced in reactors or nuclear explosions, and include those from various machines.

The radiation from radioactive materials owe their harmful effects mainly to their capacity to produce ionization in materials absorbing them. Ionization in the tissues is believed to lead to biochemical changes which, in turn, are responsible for the physiological and some of the genetic changes seen after exposure to radiation.

The intensity of the ionization, and hence the effectiveness of the radiation in producing changes in living tissues, varies with the type and energy of radiation. Alpha-particles are heavy and carry a double positive charge. Their penetration is less - they will not penetrate the skin and can be stopped by a sheet of paper and their energy is dissipated over a distance of less than 0.1 mm. Thus, in their passage through matter, they leave a trail of closely spaced ions and excited atoms.

Beta particles are lighter and have greater penetrating power. Few isotopes emit β particles of maximum range greater than 2 cm and none of them range greater than 8 cm in tissue. The rapid declaration of β particles when they pass through matter may lead to the production of X-rays.

Gamma and X-rays have an indefinite range, progressively losing their energy by interaction, in a variety of ways, with orbital electrons and nuclei in the matter through

which they pass. Electrons are ejected in the process and these produce ionization and excitation until their energy is expended. Gamma rays thus produce ionization indirectly and the ion density will be relatively small.

A. Sources of exposure

The sources of exposure of man and animals for ionizing radiation can be grouped into four major categories: (a) natural sources of irradiation, both external and internal; (b) medical sources, such as diagnostic or therapeutic X-irradiation and radiopharmaceuticals; (c) nuclear reactions, such as nuclear power reactors and nuclear weapons; and (d) other sources, such as industrial X-ray machines. Exposure to natural sources of irradiation is unavoidable for the most part, but the degree of exposure to man-made sources is subject to change, depending on intelligent and judicious use of such sources.

B. Extent of damage

The mechanism by which ionization affects living cells, and the exact nature of the cellular changes caused by it, are still not fully understood. Damage to the cell and/or plasma membranes with or without cytoplasmic changes, is claimed by some to play a major role in acute cell death. It is, however, in the nuclei that the most obvious changes are seen. Mitosis, for example, is inhibited by a radiation dose much smaller than that required to stop metabolic processes. After a small dose, temporary suppression is followed by an abnormality which is accompanied by the appearance of degenerate cells. Provided the dose is not too large, sufficient normal cells will remain to divide and repair the damaged tissue. Large doses produce immediate cell death.

There can be little doubt that profound effects such as those described above can be attributed mainly to primary damage to chromosomal material, particularly deoxyribonucleic acid (DNA). Radiation produces chromosome aberrations, of which some may cause the death of the affected cell and other alterations to the genetic material.

Not all the cells are equally susceptible to damage by radiation. The more sensitive cells in the adult animal are found in the gonads, skin, intestine, eyes and in the blood forming tissues present in the bone marrow, spleen, lymph nodes and elsewhere in the body. As would be expected, rapidly dividing embryonic neuroblasts are particularly susceptible to radiation damage.

Although nerve cells are the most radio-resistant cells in the adult body, nervous tissues of embryo and the adult neural cells of the cerebrum are radio-sensitive. Disorientation and coma are induced by brain damage at dose levels of thousands of rems.

V. ENVIRONMENTAL POLLUTANTS AND THEIR RESIDUES

Air, water, industrial and other pollutants are just as hazardous to animals as they are for humans. A good correlation is observed between animal and human toxicity problems caused by chemicals polluting the environment. The air pollution results from industrial and motor vehicle fumes being released to the atmosphere, with animals in the vicinity being exposed to sulphur and nitrogen oxides, heavy metals such as zinc and lead, hydrocarbons,

and various forms of particulate matter. Since many industrial factories are located in suburban and rural areas, livestock grazing surrounding pastures are increasingly likely to assume body burdens of these chemicals or to exhibit biologic responses to their inhalation. Lead from automobile fumes accumulates in the heavier portions of the air and in particulate matter; dogs are more likely to exhibit signs of lead poisoning than are the adult humans living in the same environment. Other common hazardous air contaminants and gases are fluorides, carbon monoxide, and hydrogen sulphide.

The water pollution is a special problem for rural areas utilizing streams and wells as municipal water sources. This is in contrast to larger cities that utilize upland reservoirs many miles distant from the consuming population. The sewage discharge of upstream communities and industrial complexes and agricultural enterprises (feedlots, crop fertilization) may result in a variety of toxic materials being present in the water used by a downstream stockman or community for drinking purposes. The same water may enter wells supplying other farmsteads or communities.

Recent interest in nitrate concentrations in water supplies has resulted in speculation as to the potential hazards of the continuous ingestion of low level nitrate waters. There is little doubt that other foreign chemicals present in water supplies due to industrial and agricultural pollution are capable of producing significant toxicity. These chemicals include arsenic, mercury, petroleum products, salts and pesticides. The toxic effects of some of these have been already discussed in this article.

In addition, there are other pollutants which can produce toxicities under circumstances that are often unique to the situation. Carbon monoxide is a special problem during winter weather in animals confined in tightly sealed quarters. Tractors or improperly vented heating equipment utilized within such facilities may produce lethal concentrations of this gas. Antifreeze (ethylene glycol) is a special problem for dogs and cats because of its sweet taste. Consumption of this material when owners discharge radiators in garages or on the ground results in toxicity due directly to the glycol or due to glycol metabolism to oxalate, which produces uremia through the urinary deposition of calcium oxalate crystals.

Coaltar (pitch, clay pigeon), chlorinated naphthalene and various phenols (creosote) are capable of entering the animal's body and producing poisoning. The severe toxicity of the various rodenticides and their wide use present a hazard for livestock and companion animals alike because of their contamination of the environment. As with most pollution problems, prevention is a matter of education and regulation and prophylactic efforts are more rewarding than treatment of poisoned individuals.

(a) Petroleum products

A variety of oils, gases, benzene hydrocarbons and other petroleum products are used on and around domestic animals. Some are employed directly on machinery to which livestock have access; several are utilized as solvents for sprays and are applied to animals. Others are formulated for application to buildings. Animal's lick or otherwise contact the applied product directly by gaining access to storage areas with open containers. In certain areas of the world oil wells and oil storage tanks provide the potential for cattle consuming crude petroleum products. Proper care and precautions are frequently not taken to ensure

that animals are protected from exposure. Incomplete fencing of crude oil storage areas may permit inquisitive cattle to satisfy their curiosity. Ignorance of the potential toxicity of these petroleum products leads owners to utilize various products directly on livestock as therapeutic aids.

Petroleum products produce a characteristic sequence of clinical signs. If applied to the skin, irritation and thickening commonly result. Photosensitization is frequent especially in white haired or light skinned individuals. If consumed by mouth, the petroleum materials produce digestive tract disturbances; inhalation results in pneumonia, and after several days can produce liver, kidney and bone marrow disfunction. Pregnant animals may abort and debilitated animals continually lose weight and eventually die. Poisoning due to petroleum products is a complicated and varied intoxication. Its occurrence could largely be prevented by educating livestock owners and by ensuring that proper precautions were taken to prevent animals' access to these materials.

(b) TCDD

TCDD (2,3,7,8-tetrachloro dibenzo-p-dioxin) is another toxic man-made chemical and perhaps the most extensively studied halogenated aromatic hydrocarbon. This chemical is found as an impurity that may be formed during the production of 2-5-trichlorophenol (2,5-T, a herbicide) or related phenols. A number of toxic effects including teratogenicity and immune suppression in animals have been reported.

(c) Feed additives

The use of chemicals added to livestock rations for the purpose of increasing feed efficiency and reducing disease is widespread in animal production. Although this practice has greatly benefitted the livestock economy, the practice is not without danger. Whenever foreign compounds are added to feeds, the possibility of error and resulting animal or human hazard increases. While the presence of chemical residues in human foods and their potential contribution to adverse effects are of most concern to public health officials, animals directly consuming feeds containing feed additives may also be poisoned. This may be due to improper mixing of the ration, incomplete following of feeding recommendations, faulty husbandry, or mismanagement. In these instances, acute poisoning results from livestock consuming feeds to which they are unaccustomed or because the feed contains unusually high levels of one or more toxic materials.

VI. PROBLEMS ASSOCIATED WITH EXPOSURE WITH VARIOUS XENOBIOTICS

On exposure, some drugs or chemicals are known to affect the immune system, reproduction and have the ability to cause cancer. The toxicology of chemicals, therefore, must take into account such problems relating to their short or long term effects in animals, wildlife, etc. For the purpose of discussion, these effects have been categorized into allergy or hypersensitivity, immune suppression, reproduction toxicity and teratogenicity, and mutagenicity and carcinogenicity. In addition, several chemicals are known to have cumulative effects or may antagonize or synergise the effects of another compound when given simultaneously or they may induce hepatic microsomal enzymes. These effects have been summarized briefly.

(a) Allergy to chemicals

The first step in the development of allergy to a chemical is the combination of a chemical with a body protein. Landsteiner referred to the chemical as a hapten. When combined with a specific body protein, an antigen is formed which will eventually lead to the formation of antibodies by the immune system. Foreign proteins, such as vaccines and antisera, act as antigens giving rise to antibodies.

An animal allergic to one drug may show allergy to related drugs. This may be due to low specificity of antibody or because the hapten is a metabolite common to many chemicals.

The most common result of the administration of any chemical or vaccine to a hypersensitive animal is the release of vasoactive amines, including histamine. This precipitates a chain of reactions leading to anaphylaxis (Gupta, 1988).

In urticaria, where the anaphylactic reaction is localized to the skin, the reaction between antigen and antibody takes place on the surface of the subcutaneous mast cells. As a result of this reaction, histamine is released from mast cells and causes dilation of neighbouring blood vessels. Plasma leaks from the dilated vessels leading to the skin thickening characteristic of urticaria.

In an anaphylactic reaction the vasoactive amines are released not only from skin mast cells but also from circulating basophils. Widespread release of histamine causes extensive peripheral vasodilation. This, in turn, produces hypotension and collapse of the animal. Histamine also produces contraction of the smooth muscles of the airways, observed clinically as dyspnoea, and contraction of muscles of the intestinal wall leading to colic and/or diarrhoea.

Many therapeutic agents have been implicated in allergies in different species of animals. Vaccines, toxoids and antisera, antibiotics, corticosteroids, hormones, insecticides as well as other drugs have been reported to cause allergies in domestic animals. These reactions are produced in some instances by the drug itself (sometimes in very small doses); in others, by breakdown products; and/or in others by stabilizing agents such as carboxymethyl cellulose, which are widely used in the drug and food industries. These agents are administered by various routes and are known to produce local reactions at the site of injection. For example, in dogs, the most frequently reported forms of allergic dermatitis are contact, atopic, flea bite, etc. Other disorders associated with allergy are eczema, urticaria, food-induced allergy, haemolytic anaemia, specific allergic enteropathies, allergic rhinitis, asthmatic cough, oedema (angioneurotic), conjunctivitis, otitis (external) and acute gastritis.

Allergy in cattle may be manifested by acute respiratory signs such as dyspnea, pulmonary emphysema, and hay fever. Causes of allergic reactions have been attributed to inhalant agents, certain feeds (in allergic laminitis) and products of protein disintegration (in retained placenta and metritis, acute gangrenous mastitis), enterotoxins (in atony and tympany), and distention of udder with milk (autoallergic reaction). All these conditions may produce only a mild syndrome of urticaria (also called hives or "bunches") or severe anaphylactic reactions, as in the case of penicillin injections or vaccination.

In horses a variety of endogenous and exogenous allergens may produce urticaria (so called wheals, nettle rash) and contract dermatitis; physical urticaria due to hot or cold stimuli is a rare condition. Other entities in which an allergic etiology is suspected are acne, purpura haemorrhagica, rhinitis, heaves or pulmonary oedema, laminitis, parturient laminitis, insect stings and streptococcal infections.

In swine, the most frequently reported urticaria reactions resulted from serum injection, a change of diet, gastrointestinal disorders. However, these conditions must be differentiated from purpura haemorrhagica, swine erysipelas and other dermal manifestations.

Although the occurrence of allergy and anaphylaxis in domestic animals is accepted but not well documented, a few documented reports indicate that allergic reaction in cows and horses observed after administration of some penicillins were due to the presence of carboxymethylcellulose in these preparations. Of all antibiotics in use, penicillin has the highest incidence of severe (720 cases) and fatal (8 cases) anaphylactoid reactions. The animals reacted within a few minutes to one half hour after injection.

(b) Immunesuppression in animals

Immune injury in human beings and animals has gained considerable experimental and clinical interest in tissue or organ transplantation. Several types of immune injury mechanisms are recognized such as anaphylaxis, cytolysis, immune complex reaction and delayed hypersensitivity. For suppression of these complicated immune reactions to transplanted tissues or organs, several groups of drugs are used clinically.

Much information is available on the small number of clinically used immunosuppressive agents. As indicated previously several excellent reviews on immunosuppressive agents have already been published and may be consulted for further reading. The compounds covered are drugs or other chemicals used for therapeutic purposes, e.g. alkylating agents (cyclophosphamide, nitrogen mustard), thiopurines (6-mercaptopurine and azothiopurines), pyrimidine nucleoside analogue (5-fluorouracil) and certain antibiotics (anthromycin, adriamycin, etc.). Several immunosuppressive compounds are listed in Table 12. It does not include other compounds, namely amethopterin, methylhydrazine derivatives, cytosine arabinosides and asperginase. Although these chemicals are recognized as effective immunosuppressive agents, they lack experimental data to support their mode of action at cellular level. Some of the drugs are specific in their action whereas a few have multiple effects on various immune systems. A brief review of four classes of well documented immunosuppressive agents is given below.

Corticosteroids, a well-known class of immunosuppressants used for clinical organ transplantation, have been shown to produce biochemical changes in lymphoid cells at the subcellular level. Increased lympholysis, reduction in phytohaemagglutinin (PHA) responsiveness, depression of delayed hypersensitivity, alteration in tumour immunity, reduction in the number of plaque forming cells (PFCs) (single cell antibody secretion), thymus atrophy, reduction in migratory inhibition factor (MIF) production and increase in the incidence of infection are some of the experimentally shown effects in animals and humans.

Thiopurines, another class of immunosuppressive agents, exert their action via both cell mediated and humoral immunity. A few well-known effects are: inhibition of PHA induced transformation of human lymphocytes, inhibition of rosette formation and depression of primary antibody response.

Alkylating agents (cyclophosphamide, busulfan, nitrogen mustard, etc.) affect T and B lymphocyte cell functions as well as effector immune mechanisms like macrophage migration and delayed hypersensitivity reaction. Yet another class of potent immunosuppressant drugs, antilymphocyte sera (ALS), is known for its multifaceted action on cell mediated and humoral immunity.

In addition, individuals ingesting large amounts of aspirin in chronic self-dosage or in accidental low dosage may have markedly depressed cell mediated immunity (CMI). The immunosuppressive properties of most of these compounds are due to their action upon rapidly dividing cells, e.g. lymphocytes, haemopoietic cells and cells of the reproductive system. Thus, their effect on the immune system is not selective. Phenytoin is another drug which may produce an unusual lymphoid hyperplastic response marked by depressed CMI and decreased IgA.

Several antibiotics, such as cyclohexamide, chloramphenicol, mitomycin-C, puromycin, streptomycin and actinomycin-D, may influence the immune response either through impairment of plaque formation (single cell antibody secretion) or through suppression of the primary antibody response. Another drug, ovalicin, also inhibits several immunological reactions in animals.

The environmental and industrial chemicals, of which some information on their effect on immune system is available, are summarized in Table 13.

The literature concerning the immune alterations currently available through laboratory animal studies and from clinical reports, suggests that an alternation of immune function is also an important aspect of environmentally induced chemical toxicity. In recent years the role of immunologic system in response to organometal compounds, ICDD and pesticides have been extensively studied (Table 12). Some of the pesticides which have reported immunological effects include DDT, dieldrin, carbaryl, carbofuran, methylparathion and endosulphan. The available data on immunosuppressive effects of many of these chemicals are inconclusive. More detailed studies of the chronic effects from long term exposure to demonstrate the effects on immunogenic response are necessary so as to have a better understanding of the effect of these chemicals on the immune system of livestock.

Table 12. Non-Exhaustive List of Immunosuppressive Agents (Wide Experimental Evidence is Available for the Products Underlined)^{1/}

Purine analogues:	<u>6-mercaptopurine</u> , <u>azathiopurine</u> , <u>thioguanine</u>
Alkylating agents:	<u>Cyclophosphamide</u> , chlorambucil, melphalan, mechalorethamine, TEM, myleran, nitrogen mustard
Folate analogues:	amethopterin, aminopterin
Pyrimidine analogues:	<u>Cytosine arabinoside</u> , BUdR, 5-fluorouracil, 5-fluoro-2'-deoxyuridine
Corticosteroids:	mitomycin C, actinomycin, chloramphenicol, azaserine, puromycin,
Antibiotics:	ovalicin, alanosine, adriamycin
Other chemicals:	methylhydrazines promethazine colchicine vinblastine vincristine 6-aminocaproic acid thalidomide chlorphenesine cinaserin salicylate
Biological agents:	<u>antilymphocyte sera</u> <u>antimacrophage sera</u> <u>phytohaemagglutinin</u> <u>L-asparaginase</u> <u>ribonuclease</u> <u>polynucleotides</u>
Ionizing radiations:	
Miscellaneous:	virus, microbial endotoxin, parasite products inducing reticulo-endothelial blockage

^{1/} from Bach, 1985

Table 13. Environmental Chemicals which are reported to have Immunobiologic Effects

Dioxins	- TCDD, TCDF
Heavy Metals	- lead, cadmium, nickel, chromium, cobalt
Organometals	- Methylmercury chloride di-N-octyltindichloride di-N-butyltindichloride
Arsenicals	- sodium arsenite and arsenate, arsenic oxide
Pesticides	- DDT, dieldrin, carbaryl, carbofuran, methylparathion
Halogenated biphenyls	- PCB, PBF
Food additives	- Callic acid, BHT
Particulate pollutants	- Carbon, silics and asbestos dust
Gaseous pollutants	- Oxides of nitrogen, sulphur dioxide, ozone and ammonia
Tobacco smoke	- Smoke, nicotine as well as water soluble fraction
Industrial chemicals	- HCB, benzene, vinyl chloride

(c) Reproduction toxicity and teratogenicity:

Several chemicals are known to affect reproductive organs or produce foetal abnormalities in animals. A number of poisonous plants and other toxins capable of producing such effects were covered earlier in this article.

In addition to these, other chemical or environmental agents such as those which have shown at least some evidence of reproduction toxicity or foetal abnormalities, are given below:

Nutritional deficiencies in the dam: deficiencies such as vitamins A and E, riboflavin, folic acid, pantothenic acid, niacin; minerals such as iodine and possibly manganese, and amino acids such as tryptophan, have been shown to cause congenital defects at least in some species. Hypervitaminoses A and D will also cause anomalies in animals.

Endocrine disturbances: diseases such as diabetes or thyroid malfunction and administration of large doses of exogenous glucocorticoids, ACTH, insulin, androgens, progestins, oestrogens, thyroxine and thiouracil cause defects of the embryo. Large doses of glucocorticoids in pregnant animals at the proper stage of gestation may also cause placentosis. Progestins given during pregnancy cause masculinisation of the genitalia of female foetuses.

Physical factors such as reduced atmospheric pressure, hypothermia, hyperthermia and anoxia cause foetal anomalies of varying degrees.

Radiation by X-ray or radioactive substances induces congenital defects.

Drugs or chemicals such as thalidomide, quinine, sulphonamides, tetracycline, streptomycin, lead, mercury, nicotine, malathion, carbon tetrachloride, selenium, fluorine, cytotoxic agents including aminopterin in sheep, nitrogen mustard, actinomycin D, 6-mercaptopurine, azoserine, azodye, trypan blue and other dyes, salicylates, histamines, ergot, "Dismox", reserpine, phenylmercuric acid, galactose, E.D.T.A. and certain plant compounds as *Veratrum californicum* and locoweeds (possibly containing lathyrogens) have all produced foetal abnormalities in animals under certain conditions.

Infections such as the viruses of bluetongue in sheep, hog cholera in swine, feline panleukopenia, bovine virus diarrhoea, mucosal disease virus, rubella or measles in women and toxoplasma, can cause anomalies in the embryo (Stephen, 1971 and Gupta, 1984).

In addition, agents such as zinc, manganese, cobalt, copper, molybdenum, cadmium, arsenic, nickel, lithium, several pesticides and PCBs have evidence of teratogenicity. Another agent, methallibure, an anterior pituitary activator or oestrus cycling control chemical for swine used in the United Kingdom, has been reported as a teratogen. Leftover feed containing this chemical was fed to swine contrary to label instructions. Exposure *in utero* resulted in a significant number of congenital abnormalities in newborn piglets.

Similarly, some environmental chemicals such as DDT, may show frequent abortions and complications in women during pregnancy and parturition. Whether such effects are

observed in animals are still unknown. Aldrin and dieldrin at lower dosage showed normal reproduction, but at higher dose levels, teratogenic and embryocidal effects have been reported in experimental animals (Gupta, 1984).

Another insecticide, chlordane at dose level of 100 ppm, may reduce viability of first and second generation mice but no teratogenic effects have been reported. A high dose of methoxychlor may lead to testicular atrophy but concrete data on reproduction and teratogenicity is lacking. Endrin at higher doses has been reported to produce some teratogenic effects in hamsters and mice but no data on low dose level is available. After exposure of rats to endosulphan no teratogenic effects have been observed. However, there is some indication of alteration in biochemical parameters of testes of rats exposed to endosulfan (Ansari and Gupta, 1983 a, b).

Several other pesticides such as carbaryl, captan, folpet, difolatan, organomercury, 2,4-5-T, pentachloronitrobenzene (PCNB), paraquat, thiram, ziram, ethylenethiourea, ethylene bisdithiocarbamates, etc., have been reported to cause teratogenic effects at least in some mammalian species and at some testable dose levels. Carbaryl can reduce fertility and at least in guinea pigs caused cervical vertebral fusion and absence of kidneys and genital organs after daily oral doses during organogenesis. Ethylenethiourea can produce malformation in the central nervous system and skeletal system of foetal rats dosed maternally with 10 to 80 mg/kg orally during gestation (Khera, 1973). Table 14 summarises a list of pesticides which show some evidence of reproductive abnormalities in animals.

For the last few years, attention has been diverted to the teratogenic effects of 2,4,5-T and 2,4-D for their possible effects on the human foetus and in other animal species. TCDD is a highly toxic compound and is a common contaminant of these herbicides. TCDD has been found to be teratogenic and other compounds containing TCDD when given during gestation lead to varying degrees of teratogenic defects. Whether pure samples of 2,4,5-T and 2,4-D can produce teratogenic effects is a controversial issue.

(d) Carcinogenicity and mutagenicity:

There are several drugs used in veterinary medicine which are suspected carcinogens or mutagens. For example, virginiamycin is used as a feed additive; triptylencamine is used to control allergic manifestations in small and large animals and also as a stimulant in dairy cows; chlorobutanol is an ingredient used in intramammary infusion products for the treatment of bovine mastitis. Similarly, several other drugs and chemicals which are commonly used may induce cancer. As per the Delaney Clause, any agent(s) which show carcinogenic effects in any animal species are not permitted at any level to be added to the food supply of human beings and, as such, in food producing animals. If they are treated with or fed such carcinogenic compounds, under this clause no residues are permitted in the edible tissue at the time of slaughter.

Since there is a large variability between a dose of aflatoxin and diethylstilbestrol (DES) that can produce cancer in laboratory animals, it is very difficult to determine a "no effect level" for a carcinogen. For example, aflatoxin is capable of inducing a carcinogenic effect at a daily dose of only a few ug/kg of body weight whereas, the dose level for DES to produce such an effect is about a thousand times greater. Yet, the consumer's concern

about 2 ppb of DES in beef liver appears to be much greater than the accepted U.S.A FDA interim tolerance level of 20 ppb for aflatoxin in cereal grains or peanuts. In as much as aflatoxin is not added by persons but is a naturally occurring toxin in nature, it appears to be much more acceptable to the consumer than manufactured chemical additives.

Table 14. Non-Exhaustive List of Pesticides which at least have some Evidence of Reproductive Abnormalities or Foetal Toxicity in Animals

INSECTICIDES	
DDT	: Abortions and complications during pregnancy and parturition
Chlordane, mirex Aldrin and Dieldrin	: Reduces viability of young
Kelvan	: Interferes with production of mammalian, avian and teleost species
Endrin, endosulphan	: Increases resorption rates
CARBAMATES	
Carbaryl	: Reduces fertility and is teratogenic (fusion of vertebrae, absence of kidney and genital organs of G. pigs)
HERBICIDES	
Paraquat, diquat	: Embryotoxic, teratogenic
2,4,5-T and 2,4-D (TCDD as contaminant)	: Teratogenic
FUNGICIDES	
Organomercury	: Neurological disorders
MISCELLANEOUS PESTICIDES	
Difolatan	: Teratogenic
Pentachloronitro benzene (PNCB)	: Teratogenic
Ethylenethiourea	: CNS malformations and skeleton abnormalities
Folpet	: Teratogenic
Thiram	: Teratogenic
Triadimefon	: Teratogenic
Deltamethrin	: Embryotoxic

To site another example, griseofulvin, when fed at very high dose levels (0.5-2.5% of the diet for 400 days), produced liver tumours in mice. Experiments of this nature are difficult to relate to clinical practice, but they should not be dismissed as unrealistic because there may exist within the population highly susceptible individuals who will succumb to low levels of the compounds.

Besides compounds which can produce cancer directly there are several drugs or chemicals, though by themselves are not carcinogenic, that are known to induce hepatic microsomal enzyme activity and thus affect the rate of steroid production and metabolism. Because of this, and due to other factors, great concern has been shown towards mutagenic and carcinogenic effect of these compounds.

The International Agency for Research in Cancer initiated a programme in 1971 to evaluate compounds for carcinogenicity. Based on available data it has been concluded that some compounds may produce tumours in experimental animals but may or may not be associated with an increase in incidence of cancer in the human population. For example, DDT has been reported to cause hepatic cell tumours in rats but there has been no information which can establish that DDT can cause hepatic cancer in the human population.

Recently, mirex has been shown to induce cancer and ethylenethiourea can cause hepatic tumours in mice. Ethylenethiourea also produces thyroid tumours in experimental animals and it is also mutagenic. Carbon tetrachloride (CCl_4) which is used as a fumigant has produced liver tumours in the mouse, hamster and rat following several routes of administration including inhalation and oral ingestion. Almost similar hepatomas have been reported in mice and rats after administration of high doses of amitrole (Gupta, 1985 and IARC, 1983).

(e) Enzyme induction

Another striking feature of low level residual pesticides is their capacity to induce hepatic microsomal enzyme activity which may, in turn, affect drug detoxification mechanisms.

A number of drugs or chemicals are capable of stimulating (inducing) enzyme activity in the liver (e.g. barbiturates, griseofulvin, phenylbutazone, DDT, etc.). Following treatment with these chemicals the increased activity of the drug metabolising liver enzymes causes more rapid metabolism of the drug itself (leading to tolerance), and also of many other drugs if these are administered at the same time, or soon afterwards. Following this effect, as much as twice the normal dose of a drug has to be administered in order to achieve and maintain normal tissue levels. A serious situation can arise when a treatment involves two drugs, one of which produces enzyme induction, thereby causing interference with the metabolism of the second drug. An example is the potentiation of barbiturate sleeping time after chloramphenicol. Intravenous chloramphenicol increased the duration of pentobarbitone anaesthesia by 120% in dogs and 260% in cats. The effect has been shown after administration by oral, intramuscular or intravenous routes and was detectable even up to 24 days after the last dose. Potentiation has also been identified between anaesthetics and aminoglycoside antibiotics.

These observations indicate that there is a greater risk of anaesthetic accidents in animals and at times the situation may be fatal or animals may develop tolerance to drugs.

(f) Secondary toxicological effects and drug interactions

Some of the drug reactions are unpredictable. Generally this is because of unusual sensitivity of the animal under treatment. There are, however, reactions in animals which are adverse but predictable because they are due to well understood secondary pharmacological actions of the drug. Such side effects are to be expected whenever these drugs are used. They are not, however, sufficiently deleterious to prevent use of the drugs for their primary pharmacological effect. For example, the sedative effects of many antihistamines do not detract from their value. Oestrogens, when used for the treatment of anal adenoma or prostatic cancer in the dog, can be expected to have a feminising effect. Androgens used for the treatment of carcinoma of the mammary gland in the bitch can be expected to have a masculinising side effect. In man, some degree of cholestasis, which may progress to jaundice, is to be expected during treatment with C17-substituted derivatives of testosterone. In addition, there are well known secondary pharmacological effects of several drugs including cortisone and related glucocorticoids.

Some antibiotics, such as penicillin, are remarkably free of adverse reactions and side effects in veterinary usage. A number of interactions with other agents may also occur, and the most serious and common of these interactions are listed in Table 15.

Table 15. Some Interactions Involving Antimicrobial Agents

Site of interaction	Agents involved	Mechanism/comment
Pharmaceutical interactions (outside the body)	Penicillins and intravenous fluids.	Penicillins stable in such fluids up to 6 hours although penicillin stable in simple 0.9% saline for 10 hours. Much less stable if bicarbonate added to drip. Always unstable in amino acid preparations and fat emulsions. Precipitation if Ca^{++} ions present (e.g. Ringer's solution).
	Tetracyclines and intravenous fluids.	Incompatible with heparin.
In gut	Tetracyclines with any agents or foods (e.g. milk) containing calcium or magnesium.	Precipitation and non-absorption of tetracycline.
	Penicillins or tetracyclines with antacid.	Decreased antibiotic absorption.
	High molecular weight antibiotics with most antidiarrhoeals.	Decreased antibiotic absorption.

Site of interaction	Agents involved	Mechanism/comment
At receptor site of non-antibiotic agent	At acetylcholine receptors, causing neuro-muscular block. All aminoglycoside antibiotics, bacitracin, colistin, interact with each other and will potentiate blocking actions of muscle relaxants, anaesthetics, barbiturates, promethazine, quinidine, sodium citrate (blood transfusions) and organophosphorus insecticides. Tetracyclines and glucocorticoids. Chloramphenicol with agents for active immunization (e.g. tetanus toxoid).	Aminoglycoside induced blockage may be reversed by neostigmine. Potentiation of catabolic effects of glucocorticoid. Depression of antibody production.
Reduced antimicrobial activity	Most bacteriostatic and bactericidal antibiotic combinations.	
Toxic interactions	Aminoglycosides with frusemide or ethacrynic acid. Tetracycline with methoxyflurane. Aminoglycosides with cephalosporins.	Progressive, cumulative and additive effects, leading to hearing loss. Potentially fatal renal toxicity (in man). Nephrotoxicity (in man).
Metabolic interactions	Chloramphenicol and tetracyclines with barbiturates, codeine, phenytoin.	These antibiotics inhibit hepatic microsomal enzymes, and thus potentiate the other agents listed even if given some time prior to administration of agents of the later group.

VII. STRATEGIES (SHORT AND LONG TERM)

1. There is an urgent need for systematic surveys for the type and extent of different toxicoses prevalent in developing countries.
2. There is a need to create awareness of the hazard produced by different kinds of toxins.
3. There is a need for implementation or strengthening of toxicoses control programmes at the national level.

4. Governments must provide facilities for intensive monitoring and laboratory analysis of various types of toxins in feed and fodders.
5. The presence or release of different kinds of toxins must be prevented during growth, harvest, transportation, processing and storage of food crops.
6. Farmers need to be educated to improve crop quality and storage conditions and to apply appropriate food processing technology.
7. National commodity standards need to be established so that livestock and human health can be safeguarded effectively through the consumption of quality foods and feedstuffs.
8. The long term objective should aim at establishing tolerance levels for various types of toxins in specific food items.
9. There is an urgent need to develop quick diagnostic kits for toxicological diseases in humans and animals.
10. There is a need for a multidisciplinary and coordinated approach devoted to problems associated with food losses due to toxicoses.
11. The international agencies should provide funds exclusively for these programmes.
12. FAO should provide funds for training programmes in toxicoses as well as to equip the laboratories of the world.
13. In order to monitor the progress of the programme, FAO Collaborating Centres should be established in each country. The progress and review of the programme should be discussed every year.

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FOOD LOSSES

COMMON CAUSES OF FOOD LOSSES DUE TO TOXICOSES IN INDIA

A. MYCOTOXICOSES

1. *Fusarium* sp.
2. *Aspergillus flavus*
3. *Penicillia* sp.
4. Deg Nala Disease

B. PESTICIDES

1. Herbicides
2. Insecticides
3. Mic Gas

C. METALS AND INORGANIC SALTS

1. Arsenic
2. Lead
3. Mercury
4. Selenium
5. Fluorine
6. Molybdenum

D. PLANTS AND THEIR TOXINS

E. ANIMAL VENOMS

F. RADIOACTIVE MATERIALS

G. INDUSTRIAL WASTES AND ENVIRONMENTAL POLLUTANTS

H. OTHER CHEMICALS AND DRUGS

POISONOUS PLANTS AND THEIR TOXINS RESPONSIBLE FOR FOOD LOSS IN INDIA

1. **PLANTS CONTAINING CYANOGENETIC GLYCOSIDES**, e.g. *Sorghum Vulgare S. Helepersis*, (Johnson Grass), Linseed Plant. *Zea mays* - Jowar, (Maize), Topioca - South India.
2. **PLANTS CONTAINING NITRATES AND NITRITES:**
Oat plant (*Avina sativa*), Wheat Plant and *Zea mays* (Maize Plant) Northern India.
3. **PLANTS PRODUCING PHOTSENSITIZATION:**
Lantana camara (Northern Hills and Plains, Central and Southern Regions), *Tribulus* sp., *Hypericum perforatum*.
4. **OXALATE CONTAINING PLANTS:**
Halogeton sp. and *Sarcobatus* sp., *Oxalis* sp. *Sarcobatus* sp. *Oxalis* sp. and *Aspergillus niger* fungus also produces on feed.
5. **THIAMINASE CONTAINING PLANTS:**
Pteridium aguilimun (Brackenfern), Northern and cause of haematuria in cattle in hill regions.
6. **SELENIUM CONTAINING PLANTS:**
Indicator plants: *Astragalus* sp., *Conopsis* sp. *Xylorrhiza* sp. *Stanleya* sp. Secondary selenium absorber plants, e.g. wheat, maize, cabbage, onion.
7. **ANTICOAGULANT CONTAINING PLANTS:**
Sweet Clover, *Melilotus alba* and *M. officinalis*.
8. **GANGRENE PRODUCING PLANTS:**
Pearl Millet infested with the fungus *Claviceps purpurea* - Central and Western parts.
9. **PLANTS CONTAINING ALKALOIDS AND GLYCOSIDES** (as Goiterogens)
Brasica sp.
10. **TOXIC PLANT ALBUMINS (TOXALBUMINS):**
Abrus precatorius, Castor Bean, Croton Beans.

**EXPERT CONSULTATION ON REDUCTION OF FOOD LOSSES
DUE TO NON-INFECTIOUS AND PRODUCTION DISEASES IN DEVELOPING
COUNTRIES**

FAO, Rome, Italy

24 - 28 June 1991

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67/1	Trypanotolerant cattle and livestock development in West and Central Africa - Vol. I, 1987 (E)
67/2	Trypanotolerant cattle and livestock development in West and Central Africa - Vol. II, 1987 (E)
68	Crossbreeding <i>Bos indicus</i> and <i>Bos taurus</i> for milk production in the tropics, 1987 (E)
69	Village milk processing, 1988 (E F S)
70	Sheep and goat meat production in the humid tropics of West Africa, 1989 (E/F)
71	The development of village-based sheep production in West Africa, 1988 (Ar E F S) (Published as Training manual for extension workers, M/S5840E)
72	Supercane as feed, 1988 (E/S)
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92	Manual on meat cold store operation and management, 1991 (E S)
93	Utilization of renewable energy sources and energy-saving technologies by small-scale milk plants and collection centres, 1992 (E)
94	Proceedings of the FAO expert consultation on the genetic aspects of trypanotolerance, 1992 (E)
95	Roots, tubers, plantains and bananas in animal feeding, 1992 (E)
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The inventory and working papers contained herein were written by experts as the basis for the first FAO Expert Consultation on Food Losses Due to Non-Infectious and Production Diseases in Developing Countries, held in Rome in June 1991. They are concerned with the occurrence, effects and control of non-infectious and production diseases grouped under the following categories: metabolic diseases, nutritional deficiencies, diseases caused by physical agents, diseases caused by inorganic or organic chemical agents, non-infectious neoplasias, genetic diseases and diseases of unknown aetiology but thought to be non-infectious.

Non-infectious diseases and disease determinants clearly influence mortality rates in young stock and result in poor fertility and other production losses such as impaired weight gain and milk, egg and wool production. Many diseases are multifactorial, involving interactions between specific disease agents and extraneous factors such as livestock nutrition and management.

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